YEARLY SUBSCRIPTION $6.00

SEP 26 192 Medical Lib.

SINGLE NUMBERS $1.00

[FOUNDED IN 1906 AS THE AMERICAN QUARTERLY OF ROENTGENOLOGY]

THE AMERICAN JOURNAL OF ROENTGENOLOGY

OFFICIAL ORGAN OF
THE AMERICAN ROENTGEN RAY SOCIETY
AND THE AMERICAN RADIUM SOCIETY

EDITOR

H. M. IMBODEN, M.D. - - - - NEW YORK

ASSOCIATE EDITOR

PERCY BROWN, M.D. - - - - - BOSTON

EDITORIAL BOARD

FREDERICK H. BAETJER, M.D. - - Baltimore
A. BÉCLÈRE, M.D. - - - - Paris
DAVID R. BOWEN, M.D. - - Philadelphia
R. D. CARMAN, M.D. - - Rochester, Minn.
JAMES T. CASE, M.D. - - - Battle Creek
A. W. CRANE, M.D. - - - Kalamazoo
A. W. GEORGE, M.D. - - - - Boston
PRESTON M. HICKEY, M.D. - - - Detroit
ROBERT KNOX, M.D. - - - - London
R. LEDOUX-LEBARD, M.D. - - - Paris
G. E. PFAHLER, M.D. - - - Philadelphia
J. S. SHEARER, PH.D. - - - - Ithaca
E. H. SKINNER, M.D. - - Kansas City, Mo.

VOLUME VIII NUMBER 9

September, 1921

PUBLISHED MONTHLY BY PAUL B. HOEBER
NEW YORK CITY

TWENTY-SECOND ANNUAL MEETING OF THE AMERICAN ROENTGEN RAY SOCIETY WILL BE HELD AT WASHINGTON, D. C., SEPTEMBER 27, 28, 29, 30, 1921

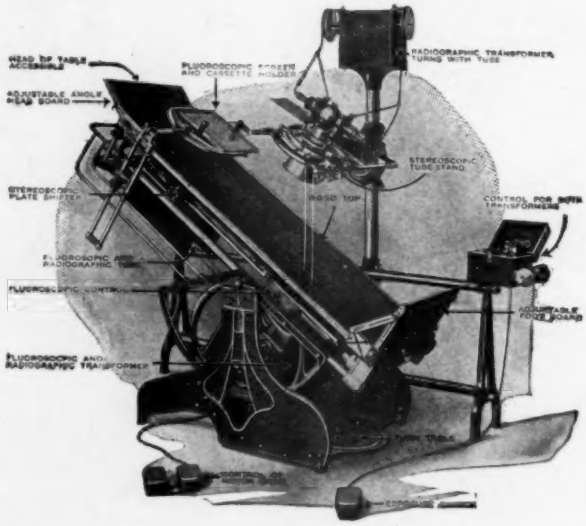
Entered as second-class matter, March 3, 1916, at the Post Office, New York, N. Y., under the Act of March 3, 1879.

Name.....
Street.....
City.....
State.....
A.
J.
R.

Send Coupon for Catalog giving complete description and a Campbell X-Ray Exposure Scale, Free

Clinix X-Ray Plant

Contrast its Appearance with that of the Old-Style X-Ray Laboratory



The CLINIX is a complete X-Ray plant.

It operates at all angles.

It is the "Aristocrat" of the X-Ray Laboratory.

You owe it to yourself and to your hospital to investigate.

Campbell ELECTRIC CO. LYNN, MASS

U. S. Patents December 19, 1911. April 22, 1913. February 29, 1916. August 7, 1917.
Also patented in foreign countries. Other patents pending. Infringers will be prosecuted.

THE AMERICAN JOURNAL OF ROENTGENOLOGY

Editor, H. M. Imboden, M.D., New York

VOL. VIII (NEW SERIES) SEPTEMBER, 1921 No. 9

SOME RECENT ADVANCES MADE IN FRANCE ON THE TECHNIQUE OF THE ROENTGEN DIAGNOSIS OF DISEASES OF THE HEART AND ITS VASCULAR PEDICLE*

BY GONZALES MARTINEZ, M.D.

SAN JUAN, PORTO RICO

HAVING just spent a year in Paris, where I went with the special intent and purpose of studying and familiarizing myself at first hand with roentgenological methods adopted in France, I thought it would perhaps interest you if I gave you a brief summary of my observations of the technique there in use for the diagnosis of the heart and its vascular pedicle.

To be perfectly frank, I prefer and consider most practical American roentgenological methods. Yet I must confess that in the limited field of cardiac roentgenology I have experienced a most agreeable surprise in observing the remarkable progress of the French investigators.

Originating in Germany with the works of Moritz, Groedel, Levy-Dorn and others, these particular methods of exploration, with the new impulse added later in England and America by Clayton, Merrill, Crane, and many others, have lately been perfected to such an extent that without fear of exaggeration one may state that the roentgenological examination of the silhouette of the heart and its large vessels occupies a place as important as that already accorded to such similar studies in the pathology of the digestive apparatus.

Many French authors have shared in this progressive movement; among them will always be mentioned the names of Destot, D'Arcelin, Béclère, Barjon, Beaujard and Thoyer-Rozat; but to Vaquez and Bordet is due the chief credit for the perfection and introduction into common practice of these new procedures, thus founding, as it were, a real school of cardiac roentgenology.

Not that they disregard in the least the real value of teleroentgenography in this particular branch of diagnosis, but yet Vaquez and Bordet prefer the fluoroscopic methods. In fact, the teleroentgenogram, although of the greatest value for permanent record of certain phases of position, actual form and relations of the cardiovascular shadow, eliminating the deformities and distortions of oblique projections, has nevertheless the disadvantage that it requires a considerable expenditure of electrical energy and the costly installation of an expensive equipment, which not everyone can afford, and at the same time they give little precise information in reference to functional disturbances. Thus teleroentgenography can hardly give us information about cardiac displacements during the movements of respiration; nor about the mobility of the cardiac apex; nor the

*Read at the Twenty-first Annual Meeting of THE AMERICAN ROENTGEN RAY SOCIETY, Minneapolis, Minn., Sept. 14-17, 1920.

expansive movements of the diaphragm; nor the respiratory profile of the thorax. And even supposing we could obtain such facts from the roentgenographic plate the procedure is so costly and complicated as to rob it of its practical value.

On the other hand, teleroentgenography could never show us exactly those modifications in volume of the left auricle; the alteration of the ventricular beats; the precise point of origin of the upper outline of the left ventricle; the angle of disappearance of the apex of the heart behind the shadow of the vertebral column as the subject is being examined in the right posterior oblique position; nor the index of ventricular depth of Vaquez and Bordet, all of which details are of immense value for the diagnosis of local affections of the cavities of the heart.

The roentgenoscopy of precision, on the other hand, as Vaquez and Bordet say, "makes the heart of the living subject appear to the observer just as it could be seen on the autopsy table, less deformed perhaps, because it is being studied while animated by the current of the blood."

Furthermore, this is a method of easy practical realization. Although it requires a certain amount of technical ability in the operator, complete knowledge of the normal, topographic and pathological anatomy of the heart and its great vessels, as well as of the various symptomatic manifestations of its different lesions, yet it does not necessitate, as does teleroentgenography, any expensive installation. In fact, an *x*-ray generator of moderate power and a simple vertical roentgenoscope provided with a suitable diaphragm and some device that would allow the tube to move independently of the fluoroscopic screen (while this can be fixed at different altitudes in front of the patient's thorax, in a plane perpendicular to the normal rays, and at variable distances from the tube) are all that is necessary.

In this respect I may mention that, in my opinion, the American roentgenoscopes are superior to the French, not only because of their adaptability and ease of movement, but also because of the greater protection afforded by them to the observer and his assistants.

Vaquez and Bordet always examine the patient standing in a frontal position, heels together, so that the biscapular axis is parallel to the screen with the costosternal wall in close contact with the screen, the chin firmly resting against its frame so as to avoid any swinging of the head and the torso. The distance between the target of the tube and the screen, according to the method of Vaquez and Bordet, must always be the same (60 centimeters), because the values that represent the normal indices of the angle of disappearance of the apex of the heart (l'angle de disparition de la pointe) and the depth development of the left ventricle, have already been calculated at this distance.

Having previously made a general inspection of the thoracic walls, the pulmonary field, the mediastinum and the median shadow, one proceeds to the tracing of the orthodiagram. The patient, meanwhile, must breathe very slowly and quietly. Locate exactly the point of origin of the outline of the left ventricle, a point which is recognized as being on that neutral zone on which you can see alternately the oscillation caused by the contractions of the auricles and ventricles. One should also mark on the outline the point where he observes the apex-beats. Once the orthodiagram is finished, Vaquez and Bordet immediately begin to determine the index of depth of ventricular development, using for this purpose a method derived from that which Strohl employs for the localization of foreign bodies. With the patient still standing in this frontal position, you ask him to make alternately forced movements of inspiration and expiration, during which you observe the displacements of the heart and study the inferior outline of the right ventricle as well as the extent of the movements of contraction and expansion of the diaphragmatic dome. The degree of mobility of the apex is investigated by having the patient bend his body to the right and to the left. The character of the cardiac and aortic pulsations will have been noted during the first part of the examination.

Next, the patient is placed in a direct posterior position, having him turn slowly with his left side as an axis, while his right shoulder comes nearer and nearer to the screen; you ascertain the exact position in which the apex of the heart hides itself, disappearing behind the shadow caused by the vertebral column, and then you measure the angle that the biscapular line forms at that moment with a plane parallel to the screen. This is the "angle of disappearance of the apex" of Vaquez and Bordet (L'angle de disparition de la pointe). This angle—which as the index of depth is found increased in all cases of hypertrophy of the left ventricle—is measured by these authors with a goniometer of their own invention.

From these direct positions the patient is put in the oblique positions, which are very important for the investigations of deformities or modifications of volume of the vascular pedicle and of the different cardiac chambers, chiefly that of the auricle and of the right ventricle. The most common of these positions are the right anterior oblique, the left anterior oblique and the right posterior oblique.

On the traced record of the orthodiagram are marked the points corresponding to the extreme limits of the contour of the left ventricle and of the right auricle, which in the accompanying illustration (Fig. 1) are indicated as the points GG′ for the left ventricle, and DD′ for the right auricle; which points are to serve for the tracing of the different diameters with which we are to calculate the global volume of the heart or the partial volume of each one of its individual chambers.

Vaquez and Bordet have adopted the horizontal and longitudinal diameters established by Clayton and Merrill, and they agree that their dimensions are in accord and relation with the weight and muscular development of the individual; but they add that they also vary with the age of the subject, such variations oscillating among average limits, the variation being from 123 millimeters of longitudinal diameter and 110 millimeters of the horizontal, in a subject of from twenty to thirty years of age whose weight does not exceed 60 kilos, up to 142 millimeters of longitudinal diameter by 132 millimeters of the horizontal in a subject past sixty years of age and with a weight of 70 to 90 kilos. The longitudinal diameter is measured by tracing a line from point D in the illustration (the point of intersection

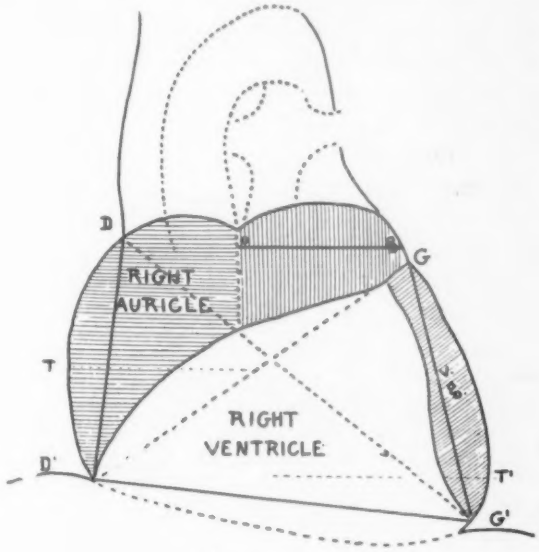


FIGURE 1.

of the outline of the right auricle with the origin of the vascular pedicle) to G′ (the point of the apex beat). It indicates the global development of the ventricles. The horizontal diameter measures the distance from the most salient part of the right cardiac contour, to the most salient of the left, and indicates also the development of the right cavities.

Vaquez and Bordet also utilize the basal diameter of Wenchebach that measures the development of the base of the ventricles, and corresponds to that line which connects points D′ (the point of intersection of the right auricular and ventricular contour) to the point G′ (the upper origin of the left ventricular contour). Its mean normal value is 99 millimeters.

Besides these diameters, important for the investigation of global alterations of form and volume of the cardiac silhouette, Vaquez and Bordet have also introduced new

diameters which facilitate the study of the partial modifications in the outline of each of the cavities. These diameters are:

(A) The left ventricular diameter or the left chord of Siciliano is the line GG′ that unites the base of the ventricle to its apex and measures the longitudinal development of this cavity. The degree of curvature of the left ventricular contour is estimated by the length of the chord of the arc which it describes, dropping from its uppermost point, a line perpendicular to the diameter GG′.

(B) The right ventricular diameter, or line D′G′ that starts from the right cardiodiaphragmatic angle and ends at the apex of the heart, measures the development of the right ventricle. It is not always very easy to determine. It is subject to some sources of error, which, if you know them, you can avoid—the descent of the point of origin of the ventricle below the right cardiodiaphragmatic angle in those pathological stages in which the heart lies on the diaphragm horizontally, and its elevation when the organ is tilted to the right by the hypertrophy and descent of its apex. To trace its chord it is necessary to have recourse to the gaseous distension of the stomach.

(C) The right auricular diameter (DD′) that unites the right cardiodiaphragmatic angle with the cardiovascular angle of the same side, and measures the volumetric development of this auricle.

(D) The left auricular diameter (line og), that connects the most salient point of the left auricular contour with the interauricular septum, arbitrarily placed by Vaquez and Bordet in the mediosternal line. This dimension is not precise and has little diagnostic value; it can be ignored because the volumetric and morphologic modifications of the left auricle can be better studied during the examination of the patient in an oblique position.

The mean normal values of these diameters are: the left ventricle, 70 to 80 millimeters; the right ventricle, 110 to 120 millimeters; the right auricular, 50 millimeters, and the left auricular, 40 to 50 millimeters. The diameter of the left ventricle has in healthy subjects the same value as an index of depth.

The record of these facts upon the orthodiagram and the record of the alterations in volume and contour observed with the examination in the oblique positions and the static and dynamic perturbations disclosed during the course of the roentgenoscopic investigations, taken into consideration with those facts given us from the clinical history, enable us in the majority of cases to make a precise roentgenologic diagnosis of each one of the lesions of the heart and its vascular pedicle, whether congenital or acquired. Just as in other branches of roentgenology, however, this does not mean that there would not occur exceptional cases in which it would be impossible to arrive at a precise conclusion; in such cases the roentgenologist has to restrict himself to pointing out those abnormalities which he has observed.

If the important improvements introduced by Vaquez and Bordet in the technique of the roentgenological examination of the heart are of great interest, of still more importance are their contributions to our knowledge of the normal appearance and pathologic aspect of the cardiovascular pedicle. These contributions have cleared up many errors of grave importance, carefully handed down in all the works of roentgenology, proving by means of experimental and clinical facts that the image of the vena cava is visible in the normal subject, and that the cylindrical shadow seen to descend (the patient being observed in the right anterior oblique position) down the clear retrocardiac space parallel to the ascending aorta, which was believed and is still thought by many roentgenologists to be the shadow corresponding to the descending portion of the aorta, is not this vessel at all but the superior vena cava.

They have also conclusively proven that the extent of the roentgenoscopic shadow of the descending aorta is very far from being that which it was formerly thought to be, in open contradiction to the classical teachings

of descriptive anatomy; but on the contrary, according to their teachings, it crosses in an oblique direction from before backwards the clear retrocardiac space, and at the level of the body of the fourth dorsal vertebra turns and descends along the left side of the spine. These observations have been later confirmed by these authors' most interesting studies on the senile aorta and by the recent and most conclusive experiments of Thoyer Rozat.

On the other hand, on account of the deep location of this segment of the vessel in the posterior mediastinum, and the considerable distance from the fluoroscopic screen, its image is not visible in the normal subject, because its shadow, weakly opaque, is lost among the clear projections from the pulmonary parenchyma and the large bronchi, and those transparent organs located behind the retrocardiac space. It is only when the aortic opacity is augmented through some pathological or senile lesion or when the clear transparency of the lungs is considerably diminished, that favorable conditions obtain for the perception of the shadow.

Starting with these precise conceptions, it has been possible to perfect the technique and to enrich our stock of knowledge of roentgenoscopic symptoms of diseases of the cardiac pedicle; for precise roentgenoscopy enables us to make simultaneously the volumetric and qualitative analysis of the large trunks which compose it, and even in some occasions of its efferent branches.

The volumetric analysis is practiced by measuring the caliber of the vessel, and, in the case of the aorta, calculating also the transverse diameter, the cord of the so-called hemicircle, or the left superior arch of the middle shadow, and the height of the aortic bend.

The caliber of the aorta, which varies with the age and build of the subject, is measured over its ascending portion, between the bend and the salient of the pulmonary artery, ranges from 10 to 20 millimeters at sixteen years of age and between 30 and 35 millimeters at sixty.

It is a dimension of the greatest clinical value when it has been carefully and accurately calculated. That is why it is important to measure it, confining oneself strictly to the rules of orthogonal projections; that is, tracing the normal ray tangentially to each one of its borders. To accomplish this, the most favorable position is the right anterior oblique, employing the *x*-rays at an approximate incidence of 35 degrees. The exactness of the obtained measurement taken must be verified by estimating again the caliber of the artery in the left antero-oblique position.

We must call attention to an error frequently made while taking this measurement. This error consists in trying to separate, with the subject in the right anterior oblique position, the shadow of the vessels from that projected by the vertebral column, by a clear space which is quite conspicuous, and while keeping the central ray in a fixed position, measuring the pedicular shadow from its anterior mediastinal border to the posterior border. Vaquez and Bordet have shown that this measure, given as that of the aorta, is not at all correct, as it includes that of the artery and part of the vena cava.

The transverse diameter of the normal aorta varies according to age, between 4 and 8 centimeters; the chord of the aortic hemicircle, from 0 to 4 centimeters. The upper border of the arch of the aorta is about 2 centimeters below the lower border of the left clavicle.

The most convenient positions for the examination of the vascular pedicle of the heart are the right anterior oblique, the left anterior oblique and the right posterior oblique. The first of these is most convenient for the examination of the ascending and descending portions of the aorta, as well as the vena cava; the second is appropriate for the examination of the transverse portion of the aorta to measure in certain cases the caliber of the pulmonary artery, and for the study of certain lesions of the venous and arterial brachiocephalic trunks, as well as the left common carotid and the left subclavian arteries; and the third one is useful for the study of the anteroposterior segment in its

terminal portion and also of the arterial brachiocephalic trunk.

There is an abnormal increase of a diameter or dimension whenever its value exceeds the normal by 5 millimeters.

The qualitative analysis of the vascular pedicle can show us the degree of density of the arterial walls, according to the more or less marked opacity to the *x*-rays; it also gives us information about the localization and character of the beats, of the greater or lesser elasticity of the arterial walls, about the enlargement and development of the aortic arch, and about any irregularity and deformity in the outline.

From the roentgenological point of view, the most important lesions which the study of the vascular pedicle of the heart offers, are aortitis and aortic aneurysm, dilatations and aneurysms of the pulmonary artery, dilatations of the vena cava and its tributary branches, and the aneurysms of the brachiocephalic trunk and of the subclavian and left common carotid arteries.

Vaquez and Bordet recognize two varieties of aortitis: (a) Those which show signs of dilatation of the vessel, easily diagnosed by the exact measurement of its caliber. (b) Those which manifest themselves by the darkness or opacity of its walls. Although in these last the artery preserves its normal caliber, it nevertheless frequently presents an enlargement of its transverse diameter, together with diminution or even obliteration of its true pulsations, and exaggerations or tortuosity and elevation of the arch.

The aneurysmal dilatations present a syndrome which is defined through the volumetric and qualitative study of its roentgenologic image, whose great axis, as well as the direction of its pulsation, will be directed according to their anatomic position and that at which the patient is being examined, to one or the other side of the median shadow if studied in the frontal position, and towards the thorax or vertebral column in an oblique position.

Vaquez and Bordet synthetize by means of the following formulae, which give a precise diagnosis, the direction most commonly followed by the salient in aneurysms of the aorta.

The aneurysms of the ascending portion of the aorta, if the sac is lateral, project, when viewed from the front, towards the right of the median shadow, and when seen in an oblique direction, towards the vertebral column, if viewed right anteriorly; and towards the thorax, if seen left anteriorly. If the sac is anterior the shadow projects constantly towards the thoracic wall and towards the vertebral column if posterior.

Aneurysms of the descending portion, when in a lateral situation, project their images towards the left, towards the thoracic wall and towards the vertebral column, respectively; when the sac is anterior, towards the thorax in the right anterior oblique position and towards the vertebral column, in the left anterior oblique; and if the sac is posterior it is invariably directed towards the vertebral column.

Aneurysms of the transverse portion of the aorta grow as a rule in a vertical direction.

As to the pulmonary artery, the study of deformities and qualitative modifications in the median arch leads with fairly good precision to the diagnosis of any dilatation, a complication so commonly found in cases of pulmonary insufficiency or stenosis. It is also at the same time possible to discover any sclerotic or atheromatous degeneration.

Dilatations of the superior vena cava, whether caused by mechanical compression from intrathoracic tumors, inflammatory process of the mediastinum, or secondary to incompetency of the right cardiac orifices, can also be diagnosed.

Exact roentgenology, the roentgenology of precision, in a word, owing to the more correct interpretation of fluoroscopic images, due to the most interesting investigations of Vaquez and Bordet, and of Thoyer Rozat, and thanks also to the recent perfections of their methods of examination, is to-day capable of solving with far more precision than any of the old clinical procedures the diagnosis of the different morbid processes of the heart and its vascular pedicle.

TUMORS OF NERVE TISSUE IN RELATION TO TREATMENT BY RADIATION*

By JAMES EWING, M.D.

Pathologist to the Memorial Hospital

NEW YORK CITY

REGARDLESS of its future as a therapeutic agent, one of the permanent contributions of radium therapy has been the demonstration of certain biological properties of malignant tumors which were previously unrecognized.

Basal cell carcinoma, in whatever one of its many forms it may appear, is regularly susceptible to radium, while squamous carcinoma is comparatively insusceptible. One could hardly anticipate that lymphosarcoma, which grows rapidly and invades tissues with destructive disregard, should melt away with surprising promptness under gamma rays. These differences, revealed by the reaction to radium, have elucidated other peculiarities in the biology of these tumors.

In general, the structural characters which determine susceptibility to radiation are a cellular character; an undifferentiated form of the cells; rapid growth with abundance of mitoses; vascularity, especially when due to abundance of delicate capillaries; and absence of much intercellular substance. On the other hand, tumors prove relatively insusceptible when the cells are differentiated and adult in type; when they grow slowly and mitoses are few; when the blood supply is through well formed adult vessels; and when there is much intercellular substance.

Considering the tumors that affect nerve tissue, in brain, meninges, spinal cord, and peripheral nerve trunks, one finds very wide variations in the above particulars, and if the rules hold, then one should expect similar variations in the response to radium.

In the peripheral nerve trunks the structure presents in the well-known *neurofibroma* or neurosarcoma several features of the resistant tumor. The cells are large or small spindles, not overnumerous, dividing slowly in accordance with the usual clinical course; and accompanied with much peculiar intercellular substance or even with definitely formed although imperfect fibrillar structures; while the blood supply is moderate with well formed blood-vessels of the type of arterioles. Accordingly one finds that this tumor is exceedingly resistant to all forms of radiation in any dosage that can safely be applied through the skin.

It is highly unfortunate that this common tumor should enjoy such resistance to radiation, for it is especially prone to recur after excision and to assume more malignant tendencies after each operation.

The dangerous character of this disease seems to deserve special emphasis, for at the Memorial Hospital during the past two years there have been received more than 100 recurrent cases of this type, in which from one to twenty-one operations had been performed. The persistence of these recurrences is quite remarkable. Even after wide excision, the neighboring tissues seem to join forces in providing new tumor tissue, as though the nerve filaments on all sides of the growth had the capacity to excite growth of neoplastic cells, after the manner in which the primitive neuroblasts are said to provide themselves with sheaths from the tissues in which they travel. Or the recurrent tumor may develop anew in an adjoining segment of the affected nerve trunk, which in many cases is condemned to tumor growth throughout much of its extent.

Most of these tumors pass unrecognized and fall in the general designation 'sarcoma.' Yet the structure of intertwining fibrils and long spindle cells is quite specific and easily recognized. They are quite different in reaction to radium from the soft and vascular fascial sarcomas.

The exact form in which these dangerous

* Read before the New York Neurological Society, New York Academy of Medicine, Dec. 7, 1920.

tumors first appear is not entirely clear, but many of them are regarded as innocent movable tumors of the subcutaneous tissue or intermuscular planes. In attacking such a tumor the surgeon should realize that he is undertaking a very serious problem and that if operation is not successful he can expect little aid from physical agents. Neurofibroma of the acoustic nerve has a generally unfavorable prognosis, but there is a myxoglioma of the optic nerve occurring in young subjects, which is readily enucleable and does not recur.

Endothelioma.—There are several different structural types of tumors of brain, cord, and meninges which are commonly referred to an endothelial origin.

Psammoma, or sand tumor, is a frequent, well-known, slowly growing, hard, single or multiple tumor of the meninges, affecting either brain or cord, and sometimes extending all over the cerebrospinal meninges. It is composed of dense concentric masses of meningeal lining cells, and arises from the so-called endothelial buds of the dura mater. It does not seem possible that radiation can have more than a mild inhibiting influence on such a tissue, unless radium is applied directly to the tumor or inserted within it. Since they are usually located in the dura, this mode of treatment should often be possible.

Rarely one encounters vascular and cellular endotheliomas which may be more susceptible; but whenever the cells are of adult endothelial type and of pavement form, they cannot be regarded as a very favorable type for treatment by radiation, unless radium can be inserted within the tumor.

True angio-endothelioma, or perithelioma, occurs in the meninges and substance of brain and cord, as well as along the peripheral nerve trunks as they emerge from the cord in the spinal canal. These tumors are composed of large polyhedral or cubical, occasionally flattened cells, surrounding blood channels. Groups of such cells occur in the rare diffuse sarcoma of spinal meninges. They should be more susceptible to radium.

Angiosarcoma is the common tumor of the sarcomatous class that occurs in the brain. It appears to arise from the cells composing the blood-vessels, and is one of the few examples of a true mesoblastic sarcoma arising from blood-vessels. It grows rapidly; often reaches large dimensions; is generally encapsulated as contrasted with glioma; and it is soft, highly vascular, and subject to hemorrhages. It is one of the few tumors that has been satisfactorily traced to a traumatic origin.

As far as the tissue itself is concerned this tumor ought to be markedly influenced by radiation, since its nutrition is very unstable; but whether a slow and safe regression can be accomplished appears doubtful, especially with bulky tumors. On the other hand very few successful surgical removals of such growths have ever been accomplished, so that they are legitimate territory for experimentation with physical agents.

Glioma.—Of all tumors of brain and spinal cord, glioma in its various forms presents most of the structural features that favor susceptibility to radiation. They are cellular, sometimes extremely so; the cells are of delicate construction and labile chemical constitution, which render them very prone to autolysis and liquefaction; the blood-vessels are numerous and very fragile, and the tumors are notably subject to hemorrhage and necrosis. They are by far the most frequent brain tumor, forming 55 per cent of all tumors, including fibromas, cysts, and tubercle. (Tooth.) They are chiefly cortical, and their sites of election are the cerebellum and the frontal lobes. Unfavorable features are their comparatively rapid growth, lack of encapsulation and the secondary effects on surrounding brain tissue.

Three main types of glioma may be recognized: Astrocytoma, typical adult glioma with glia cells and fibrils; Gliosarcoma, which is anaplastic and very cellular; and Neuro-epithelioma, which is the embryonal form. Only the astrocytoma contains anything like a resistant intercellular material, and this is usually poorly formed and scanty. Extravasated blood and cystic collections of fluid form a considerable portion of the

bulk of many gliomas, and are quite as effective in producing pressure as growing tumor cells.

On the whole I know of no tumor which on *a priori* grounds ought to yield more readily to moderate radiation than the average glioma.

Primary *carcinoma* of the brain arises from the lining cells of the choroid plexus. Although originally derived from neuroblasts these lining cells have acquired the properties of lining epithelium. The resulting tumors take the embryonal type of ependymal glioma, or more frequently the adult type of papillary adenocarcinoma. These adenocarcinomas occupy the lateral *ventricle,* seldom reach dimensions exceeding 4 to 5 cm. in diameter, and they are composed of very delicate mucinous stroma supporting fragile capillaries and lined by coherent masses of small delicate polyhedral cells. The growth is slow. Their structure indicates a high degree of susceptibility to radium. More coarsely built adult papillary adenocarcinomas occur which seem to arise from the velum interpositum.

In the region of the third ventricle project the very delicately structured cellular tumors of the pineal gland. In the fourth ventricle are found chiefly gliomas and angiomas, the latter quite beyond the reach of either knife or physical agent. From this region I have recently seen a papillary neuroepithelioma of very delicate and vascular structure. The patient succumbed to exploratory operation.

All these tumors along the center of the brain axis are well protected by distance from the attack by radiation, but their very delicate structure encourages the hope that they may in some instances be favorably influenced by the physical agents.

The group of *hypophyseal tumors* includes cysts, chronic adenomatoid hyperplasia, cellular adenocarcinoma, glioma, and hypophyseal duct tumors.

There are no data suggesting that radium can affect the accumulation of fluid in the cysts.

Chronic hypophyseal struma with acromegaly has already been definitely influenced by *x*-rays directed through the temporal regions. Béclère's results, especially, encourage the effort to control these partial tumor processes by the physical agents and to devise more direct means of access to them by surgery. Quick has already reported on the efforts made in this field at the Memorial Hospital, and it is our belief that success will eventually be attained by exposing these tumors for direct radiation or by inserting minute quantities of radium within them. It cannot be said that hypophyseal struma, being a form of functional hyperplasia, is very susceptible to radiation. The cellular adenocarcinomas are more so. In either case the bulk of the tumor should render the insertion of radium a safe procedure, if infection can be avoided.

The hypophyseal duct tumors belong in the class of basal cell carcinomas of the salivary gland type. In the salivary glands these tumors respond well to radium but regression is very slow. In the hypophysis the tumors are usually cystic.

The slow course of most hypophyseal growths and the peculiar clinical symptoms due to functional disturbance of the endocrine system provide very delicate indicators of any therapeutic effect that may be produced upon them, and render this field of unusual interest in radium therapy.

The possibility of applying radium successfully and safely to intracranial and intraspinal tumors depends on several factors. Chief among these is the obstacle presented by the skull. In the adult the average thickness of the skull is about 5 to 6 millimeters. This thickness of bone tissue, it has been found, will absorb between 2 per cent and 3 per cent of the gamma rays which pass through 2 millimeters of brass. Accordingly the dosage would have to be increased to meet this loss, if one is to deliver a radiation known to be effective with other more exposed tumors. Yet this result can be accomplished by increasing the quantity of radium used, as well as the distance and time factors, but it must be recognized that an additional difficulty exists which is not en-

countered with other less protected tumors.

The distance of many tumors from the scalp, especially those lying centrally, or at the base of the brain, is an even greater handicap than the absorption by the skull, for the radiation diminishes as the square of the distance. To meet this difficulty a further increase in dosage, distance and time must be provided. Hence it would appear that the effective treatment of brain tumors by external radiation will require so much radium as to restrict this method to institutions possessing large amounts. Since only cellular tumors can be definitely influenced by heavily filtered radium at a distance, the method is still further limited to such types, which are mainly the gliomas, and cellular tumors of neuro-epithelium and ependymal cells.

In children, the comparative thinness of the skull, smaller size of brain, and more frequent occurrence of cellular tumors suggests that external radiation should first be employed before proceeding to other methods.

That an effective dosage of radiation can be delivered through the adult skull to all portions of the brain, sufficient to influence the growth of cellular tumors, can be shown by physical computation, and has been demonstrated experimentally by the work of Dr. Bagg on dogs and monkeys. Whether such dosage will prove sufficient to bring to a standstill or to definite regression any of these tumors, can be determined only by actual experiment on the human subject. It is sufficient to point out that the use of radium in such cases, is not a mere placebo.

Two thousand millicuries of emanation filtered through 2 mm. of brass and placed for six hours at a distance of 6 to 10 cm. from the skin, has often produced rapid regression of deep glandular carcinomas, metastases of testicular carcinoma in the epigastric region, and retroperitoneal lymphosarcoma. A reduction of 10 per cent for the absorption by the skull and brain can readily be met by increasing either dosage or time. The hair of the scalp will be sacrificed, but the cuticle need not be injured. Nor has such dosage produced definite subjective cerebral symptoms during its application or afterwards.

In the brains of normal dogs and monkeys these dosages have not, in Bagg's observations, produced any structural changes, or any demonstrable symptoms. In fact it appears that very much higher dosage, resulting in a caustic necrosis of the scalp, may be tolerated without yielding structural changes in the normal brain. It has been upon this experimental evidence that we have felt justified in employing large dosage over the brain in subjects suffering from brain tumors, and the cases exhibited this evening, which have been thus treated, confirm our conclusions regarding the safety of the dosage.

But the brains of subjects of intracranial tumors are not as a rule normal. Especially with actively growing vascular gliomas and sarcomas, and even with slowly growing localized endotheliomas, as shown by Collier, the circulation of the brain is often disturbed, and acute or chronic edema may affect a large portion or the whole of one hemisphere, giving rise to many peculiar secondary symptoms. General intracranial pressure is often at the upper limit of safety or even beyond it, with all types of intracranial growths. Flattening of the convolutions, capillary anemia, ventricular hydrops, miliary hemorrhages, and exudative and degenerative changes, are some of the anatomical conditions that may complicate the tumor. In twenty of twenty-nine cases, mostly of cerebellar tumors, Batten and Collier found that distention of the spinal arachnoid had produced degeneration of the posterior columns and ganglia, with stretching, tearing, and compression of the nerve roots.

Under such conditions the effects of radium application may be quite different from those observed in normal brains and cords. Full radium dosage may be expected to produce hyperemia, increase of intracranial pressure, and probably some edema, before it can cause any definite recession in the bulk of a tumor. Therefore, unless the patient can withstand a certain temporary increase in

pressure, the application of radium may be followed by aggravated symptoms.

When the tumor can be exposed, it becomes accessible to direct application of radium, or to the insertion of emanation needles. The last method is undoubtedly the most effective in dealing with the tumor, without regard to its structure, but it is accompanied by the danger of infection, and the risk of damaging normal brain tissue. Tissues affected by radium are undoubtedly more susceptible to infection than normal tissues, but one can hardly question the capacity of modern surgical technique to cope with this matter. As for the damage to normal brain tissue, Bagg's experiments show a remarkably uniform and sharply demarcated zone beyond which the effects of radium on normal brain tissue are negligible. If radium needles are to be used it is highly important that the tumor tissue should not be disturbed by partial excision, as the tumor tissue acts as a filter protecting the normal unaffected areas.

The practice of attempting to remove as much as possible of the tumor and then turning the case over for radium treatment generally assures a failure and discredits radium therapy. With few exceptions, if a brain tumor is to be treated by radium, surgery should be used only to expose the tumor. A cordial cooperation and mutual understanding between surgeon and radiologist are essential if any success is to be achieved in this field.

Any attempt to suggest the scope and limitations of radium therapy of brain tumors, on theoretical grounds, is obviously surrounded by so many possibilities of error, that the undertaking may well prove useless or even presumptuous. In nearly all respects the problem is a clinical research, to be undertaken by the experienced neurological surgeon and the radium expert, and the only safe guide is experience. If there is any justification for the discussion presented in the present paper, it is found in the review of those invariable actions of radium which have been observed in other fields, and the analysis of the structure of brain tumors as they are found to occur. Without this knowledge as a basis the neurological surgeon, and the radiologist as well, are helpless in attempting to form an estimate of the indications for radium in this field, or in judging of its results.

SYPHILIS OF THE LUNGS, ITS RADIOGRAPHIC FINDINGS AND THEIR PATHOLOGIC BASIS*

By ROSS GOLDEN, M.D.

House Physician to the *X*-Ray Department, Massachusetts General Hospital

BOSTON, MASSACHUSETTS

SYPHILITIC infection of the lung is not a common disease, but that it does occur and that it is mistaken for other pulmonary diseases there can be little doubt. The diagnosis is difficult, particularly in the earlier stages. Most of the modern writers mention the roentgen ray method of examination as being of assistance; and if there are appearances suggestive of syphilis of the lung on the *x*-ray plate, their recognition is certainly of vast importance to the occasional sufferer from this affliction, especially in the differentiation of pulmonary tuberculosis, because a correct diagnosis means specific treatment and relief.

Pneumonia alba fetalis is universally recognized and will not be considered in this discussion.

INCIDENCE.—At a luncheon table recently, a pathologist and a surgeon were sitting side by side. The subject of syphilis of the lung came up. The pathologist remarked: "Syphilis of the lung has never been proven to exist." "Certainly it exists," said the surgeon; "I can show you a case." Thus is defined two points of view, the ultra-scientific and the clinical. Those looking at the question from the clinical side are hoping that histological technique may be improved so that incontrovertible proof may be furnished by the demonstration of the treponema pallidum in pulmonary lesions as it has been in the aorta and brain.

Osler[1] refers to pulmonary syphilis as a "very rare disease." In 2,800 autopsies at the Johns Hopkins Hospital, there were 12 cases, in 11 of which there were definite gummata. Two were suspected clinically. Fowler could find only 12 specimens in the museums of London, two of which were doubtful. Lord[2] states that among 3,000 autopsies at the Massachusetts General Hospital, there was one case with syphilitic ulceration of the trachea and indurative pneumonia with cavity formation. The syphilitic nature of the pulmonary lesions was considered doubtful. Carrera[3] recently made a pathological study of the lungs in 152 autopsy cases of syphilis. Among these he found 12, or 8 per cent, which he believes show unmistakable evidences of syphilis. Osler remarks that the pathological diagnosis depends a good deal on the conception of the individual pathologist as to what constitutes a syphilitic lesion.

From the clinical side, McCrae and Funk[4] found in 1200 cases referred to the Jefferson Chest Hospital as being unquestionably tuberculous, 72 which were non-tuberculous, of which number 4 had pulmonary syphilis. On the other hand, Carrera quotes Otis as having stated that in his experience he had not found a case which he believed to be syphilis of the lung. Post[5] reported two cases in 1916 which he believed to be syphilis of the lung. One of these has since returned to the Massachusetts General Hospital and will be discussed below. In the wards of the Massachusetts General Hospital 5 diagnoses of syphilis of the lungs have been made, all since 1908, and two of them are followed by a question mark. Two of these diagnoses involved the same case on two admissions eleven years apart.

Watkins,[6] who has been particularly interested in this question from a roentgenological point of view, reports that out of 5,000 *x*-ray examinations of the heart and lungs, 146 cases, approximately 3 per cent, were diagnosed, positively, or probably, as uncomplicated lung syphilis and 68 cases as combined tuberculosis and syphilis. He believes the latter figure is far below the actual incidence of this combination.

*Read before the New England Roentgen Ray Society, April 2, 1921.

PATHOLOGY.—In the interpretation of radiographs, we attempt to read the shadows representing the various degrees of density in the part through which the rays have passed in terms of pathology. In the discussion of this subject, it may be of advantage to reason the other way around, that is, from pathology to the shadows which might be expected on the *x*-ray plate. A valuable review of the literature from the pathological point of view has been published recently by Carrera[3] along with his report of the study of the lungs in 152 cases of syphilis. From this and other articles the following points which might be of importance from the *x*-ray standpoint, are taken.

Two chief types of lesions have been described: the gumma, and fibrosis or chronic interstitial pneumonia.

Cases of gumma of the lungs have been described by many writers. Some of the points emphasized as characteristic are: the multiple occurrence of the gumma; its subcommitant pleural thickening; and the extraordinary cicatrization of the lesion. Most writers say that a gumma rarely appears in the apex, and all agree that the right lung is more frequently affected.

The characteristics described as typical of chronic interstitial pneumonia or sclerosis are as follows: Diffuse infiltration localized in the middle or lower portions of the lung with sclerosis of the bronchi which may be dilated. Sclerotic tissue radiates from the hilum or from the pleura, may extend to the farthest zones of the lungs and may give to the lung a lobulated appearance. Around the bronchi and vessels, the thickening is constantly found, and in some places the alveolar walls are thickened. All writers agree that bundles of connective tissue radiate from the pleura, in many cases crossing the lung from side to side. Pye-Smith[7] regards peribronchial gummas or plaques as the starting point of the process and the bronchiectasis as the result. Roessle[7] states that the characteristic changes in chronic interstitial pneumonia are peribronchitis and periangitis, thickening of the alveolar walls and new formation of a network of connective tissue. The lesion affects chiefly the lower lobes. No secondary collapse of the lung takes place.

Syphilitic lesions of the pleura were believed by the older authors to exist. Sadowski[7] saw a case of gumma of the pleura. Raymond[7] accepted the existence of an exudative syphilitic pleuritis. Hamman[8] states that in chronic cases of pulmonary syphilis the pleura is often involved and great thickening of this tissue may accentuate the pulmonary sclerosis. Carrera in his own cases found that old pleuritic adhesions and thickenings were common, but the changes could not be identified as characteristic of syphilis. Schupfer[9] reported a case of pleuritic involvement which subsided under antisyphilitic treatment, but believes that this and the majority of cases in the literature are of tuberculous origin. His opinion is apparently based, in part at least, upon the fact that he has traced many of the cases of supposed syphilitic pleurisy and has found that they developed frank tuberculosis later. The writer recently observed over a period of months a case (to be reported elsewhere) which came to the hospital with a rapidly recurring hydrothorax, the fluid being of the exudative type and sterile. Guinea pig innoculation gave a negative result. The effusion quickly cleared up under antisyphilitic treatment and the patient has gained weight and has been about her work for over six months. The burden of proof would seem to be upon him who states that in such a case the pleurisy was of tuberculous origin. A patient having had a syphilitic pleurisy might develop active tuberculosis later.

Hamman[8] remarks that syphilis is common in the upper respiratory passages and rare in the lungs, while the opposite is true of tuberculosis. The point of bifurcation of the trachea is a favorite location of syphilitic ulceration. As the lesion heals contraction occurs and one of the main bronchi may become occluded, resulting in extreme bronchiectasis and fibrosis. Lord[2] calls attention to the fact that in cases in which tracheobronchial syphilis is present, bronchostenosis may give rise to inflammatory and indura-

tive changes in the pulmonary territory supplied by the stenotic bronchus without actual invasion of lung tissue by the syphilitic virus. According to Carrera, the occurrence of syphilitic thickening of the bronchi has been emphasized by many writers and many have ascribed a syphilitic origin to bronchiectasis. Osler and Gibson[7] state that bronchiectatic cavities may be associated with a syphilitic pneumonic process, and that a lung may be excavated by a bronchial dilatation in the same way as from an aneurysm. Nodal[10] remarks that the pulmonary scleroses in congenital syphilitic children involve to a variable degree the pleurae and the lungs. They are invariably accompanied by bronchiectasis. The condition is often misinterpreted as cavernous tuberculosis, pneumonia, pleurisy or simple bronchitis.

Carrera divides his cases into two classes: (1) Gumma with peribronchial lesions and arteritis. (2) Fibrosis and arteritis.

Syphilitic fibrosis takes its inception, he states, in a typical inflammatory process due to the local action of the spirochetes, and is the termination of the syphilitic process. It should extend along the vessels and bronchi as well. He also studied connective tissue formation in 60 cases of tuberculosis and is convinced that it is never impossible to distinguish the two. The scar of the tubercle is round, sharply delimited, more frequently calcified and often very confluent or conglomerated. The scar of syphilis is irregularly radiating or stellate and not sharply delimited. The scars of gummas are extremely rarely conglomerated or confluent. The syphilitic fibrosis begins under the pleura and around the bronchi and is more frequently anthracosed and very rarely calcified. He does not discuss the gross distribution of the lesions in these cases.

THE RADIOGRAPH.— It is evident from the foregoing that the possibilities for variation in individual cases of syphilis of the lung are manifold, and that it would be difficult to make a satisfactory classification from the *x*-ray standpoint. However, in view of the pathology of this condition, three different types might be expected; two corresponding to Carrera's two types, i.e., (1) gumma with peribronchitis, and (2) fibrosis; and the third resulting from bronchostenosis with or without actual parenchymal involvement. The pathological descriptions are definite and their relations to the shadows on the *x*-ray plate are more or less self-evident. A few points in connection with each type may be worth mentioning. The frequency with which pleural involvement has been found should be borne in mind.

1. *Gumma with Peribronchitis.*—This type, of course, would vary with the progress of the disease. In its early stages it would show bronchial markings with small knobby enlargements due to small peribronchial gummata. Figure 2 is an example. Later the picture would be modified by the increase in numbers and size of the gummata, by scar formation resulting in linear shadows radiating from hilus or pleura with contraction of the lung and retraction of the mediastinal contents, and by increasing pleural involvement. Figure 3, the same case as Figure 2 but five years later, is an example. The process develops from the hilus outward, and it is the consensus of opinion that it prefers the lower portions of the lung. It tends to develop extensively in one lung, which is more apt to be the right according to the literature, leaving the other relatively clear, e.g., the left lung in Figure 3. The shadow of the gumma should be rather irregular in outline, poorly defined, and, when cicatrized, radiating or stellate, and rarely if ever calcified.

2. *Syphilitic Fibrosis.*—This may give a rather diffuse increase in bronchial shadows without evident gummatous enlargements, as is suggested by right lung in Figure 4.

3. *Bronchostenosis.*—The result of stenosis of a bronchus is collapse of the lung followed by extreme pathological changes. On the *x*-ray plate, there is absolute dulness involving one whole side with marked retraction of the heart and mediastinum to that side. Figure 1 and possibly Figure 4 are

examples. The same shadows might be given by the first type mentioned, gumma with peribronchitis, if the process had continued far enough.

The above discussion has been confined to the later manifestations of syphilis. The fact that there may be pulmonary signs in the secondary stage is well known. Funk[4] refers to the possibility of confusing the râles which may be present in the apices in patients with secondary syphilis with those of early tuberculosis. Dunham[11] describes a case with luetic mucous lesions of the mouth, which showed diminished excursion of the diaphragm on the right side and prolonged expiration with fine dry and subcrepitant râles in the right upper chest. The plates showed nothing abnormal. The physical signs cleared up after one dose of salvarsan. He remarks that although the "syphilitic catarrh" may give physical signs which minutely simulate those of early tuberculosis, it leaves no record on the *x*-ray plate, a fact of some importance in differential diagnosis.

Diagnosis.—The diagnosis must depend on all the facts available from the history, physical examination and laboratory findings. The affinity of tuberculosis for the upper part of the lungs and its tendency to be bilateral are well known. Resolving or unresolved pneumonia, malignancy[12] and massive collapse of the lung of traumatic origin, must be borne in mind, as they may cast shadows indistinguishable from those of lung syphilis. A case was recently seen in this laboratory which showed homogeneous dulness throughout the left chest with marked retraction of the heart to that side, suggesting collapse of the lung. Syphilis of the lung was mentioned as a possibility to be considered. The patient, however, had a history of trauma, a fall from a wagon, from which his symptoms dated. Re-examination a few days later showed a hydropneumothorax, ruling out the possibility of lung syphilis and favoring massive traumatic collapse of the lung.[13] Dr. Post[5] mentions a case in which *x*-ray examination showed one whole side to be dull and which at autopsy was found to be malignant. The roentgenologist will certainly be of great service if he does nothing more in suspicious cases than to direct attention to the possibility of syphilitic involvement of the lungs.

In summary, the following points may be worthy of mention. When syphilis attacks the lungs, it prefers the lower part, seldom involving the apex. The process is apt to be more marked around the hilus, progressing from this part of the lung along the bronchi toward the periphery. It tends to develop unilaterally and may completely destroy the function of one lung, involving the other comparatively little or not at all. It involves the pleura extensively and causes a marked connective tissue reaction, producing radiating or stellate scars which may be very extensive and which calcify rarely. Three general types of roentgenogram may be expected, based upon three ways in which this condition may develop pathologically:

1. Gummata with syphilitic peribronchial infiltration.
2. Syphilitic peribronchial fibrosis.
3. Bronchostenosis with collapse of the lung, resulting from syphilitic ulceration of a bronchus.

The following cases are appended as illustrative. Nos. I and II are, from the clinical standpoint, quite certainly syphilis of the lungs. In Case III, this diagnosis is very probable, but the patient was not observed long enough to make it certain.

CASES

Case 1 (Fig. 1). M. Female, age twenty-five years. Father had locomotor ataxia. One brother, age twenty-nine, living and well. Three sisters born next died in early infancy. Two children stillborn. Tuberculosis in aunts and uncles on both sides.

Infantile paralysis at six affecting the left side. Pneumonia at six. Diphtheria at thirteen. Has been in a hospital four times for "chest trouble," the last time in 1911. Was a patient in a State tuberculosis hospital for ten months in 1910–11. A report from

that institution gives the following facts: "Rough breathing and a few râles at the tops of both lungs. Sputum examination repeatedly negative. Temperature 96.8–99.4 degrees. Pulse 80–100. Record does not indicate any material change in physical signs during stay in hospital. Gained 6 pounds in weight and was discharged as improved. No *x*-ray was taken." In 1912 patient went

FIG. 1. CASE I. Diffuse dulness throughout the left chest, obliterating the outlines of the heart and diaphragm. Marked retraction of the heart and mediastinal contents toward the affected side. The right lung field is clear. Bronchostenosis with collapse of the left lung. This case was reported by Dr. Abner Post in 1916. A comparison of this plate with the one published at that time shows no change in the appearance of the chest.

to the Eye and Ear Infirmary with interstitial keratitis. In 1913 she was given two injections of old salvarsan at the Boston Dispensary. In 1914 she was admitted to the Massachusetts General Hospital complaining of pain in the left hip. Physical examination at that time gave the following facts: Small, deformed, decidedly deaf. Ground-glass appearance to cornea. Pupils irregular but react to light and distance. Radiating scars at corners of mouth. Scaphoid scapulae, clavicles short. Left chest smaller than the right with little respiratory motion. Over the left front and back dulness and increased breath and voice sounds. Few dry râles. Over left back a marked rub was heard synchronous with the heart beat. "Cracked pot" sound at the left base behind. Heart: Apex was felt in the fifth space 15 cm. to the left of midsternal line. Spleen just palpable. Peroneal group of muscles atrophied on the left leg. Luetin reaction positive. Temperature normal. *X*-ray report: "The left chest is dull throughout, more dense at base. Heart and trachea are displaced to the left. There is apparently very little sound lung tissue on the left side. Right chest negative. Extensive chronic process involving the left side of the chest, probably not tuberculosis, may be syphilis."

In December, 1920, she reappeared at the Out-Patient Department, complaining of cough and shortness of breath on exertion, and was admitted to the Hospital. She was totally blind and was deaf to all but the loudest sounds. For the previous two months there had been increasing urinary frequency and some incontinence. Examination of the chest showed signs on the left side about as in 1914, except there were many râles. The right chest showed dulness above the second rib, and diminished breath sounds throughout. Apex of the heart was not felt. Blood Pressure, 122-78. No clubbed fingers. Urine negative. White count, 14,000, 16,000. Provocative Wassermann negative. Spinal fluid negative. Eye consultant: "—Sure that the eye represents some form of lues." Ear consultant: "—Marked nerve deafness. Probably specific." *X*-ray, December, 30, 1920: "Appearance is practically the same as described in 1914. The entire left side is dull. Heart and mediastinal contents are displaced to the left. Trachea can be seen to the left of the spinal column. The appearance is that of an extensive destructive process involving the left lung. Lues should be considered." Temperature normal except on two occasions when it reached 100°. Discharge diagnosis: Old anterior poliomyelitis. Congenital syphilis. Fibrosis left lung, (?) syphilitic.

Discussion.—This case was the second of the two reported by Dr. Post in 1916. A comparison of the plate taken in 1920 with

the one made in 1914 and published in his article shows absolutely no change in the appearance of the chest. It represents the type which we believe is due primarily to bronchostenosis, although actual syphilitic invasion of the lung may be associated. Unfortunately, data as to antispecific treatment is not at hand. Probably, in a case as far advanced as this with such extensive cicatrization, little change in the *x*-ray plate would be seen as the result of antiluetic medication, although clinical improvement might be marked. In Dr. Post's first case, the only change in the picture three years after beginning treatment was a diminution in density over a small area at the level of the first interspace, yet this patient was doing his daily work and was "passing among his friends as a healthy man."

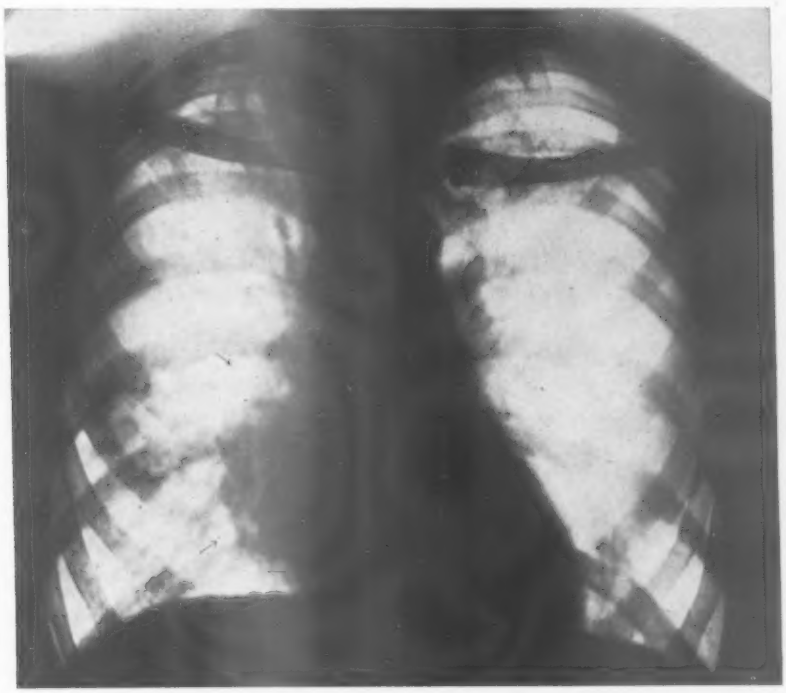


FIG. 2. CASE II (1914). Marked thickening and irregular coarse beading of the bronchial shadows. Mottled dulness along the right lung margin. Dense shadows about the right hilus extending down nearly to the diaphragm. Gummata with peribronchitis at a relatively early stage.

CASE II (Figs. 2 and 3). G. Male, white, age forty.

Appeared at the Out-Patient Department in 1906, with a Neisser infection and secondary syphilitic lesions of the mouth and skin. The former extended to the seminal vesicles, compelling the patient to undergo a long series of treatments in the G. U. Department. The latter gradually responded to proto-iodide of mercury pills and KI. In 1908, he was admitted to the wards of the hospital complaining of a severe cough and raising about a pint of greenish purulent sputum daily. Three months and one month before admission, he raised a wineglassful of dark blood. He had no night-sweats and said that he felt well. Physical examination of the chest showed slight dulness, diminished breathing and voice sounds with occasional crackling râles at the end of deep inspiration at the right base in the axilla and behind. Elsewhere the lungs were not remarkable. The sputum during his stay in the Hospital was small in amount and showed no tubercle bacilli or elastic fibrils. Tuberculin skin test was positive. His temperature was usually normal. Its highest point was 100.8 degrees. There was no daily variation.

His weight was 138 pounds. The diagnosis on discharge was: (?) Syphilis of the lung, (?) Tuberculosis. The *x*-ray report on the Out-Patient record is: "Generally negative. Apparently something in both apices. Fusiform swelling of the left clavicle." This report was apparently written into the record from memory by the clinician after a consultation over the plate with the roentgenologist, and is not a copy of the words dictated by the latter. During the succeeding year

FIG. 3. CASE II (1919). Dulness over entire right chest, most dense at base, obliterating the outlines of the diaphragm and the right border of the heart. In the upper part of the dull area is a coarse mottled appearance. Heart is somewhat drawn toward the affected side. On the left the hilus shadow is increased in density and there is a diffuse peribronchial fibrosis. On the right, gummata with peribronchitis at a later stage.

after discharge the patient continued to take mercury and KI by mouth until a slight stomatitis developed. On one occasion, in 1909, his temperature was 99.7 degrees, his weight was 149 pounds and his Wassermann test was positive. He continued to cough and raise some sputum but felt quite well. In the early part of 1910, his weight was 156 pounds, a gain of 15 pounds over the weight in 1908. He was not seen in the Out-Patient Department again until the middle of 1914, when he came in with the story that he had spat up clear blood on three days of the preceding week. No tubercle bacilli were found in the sputum. *X*-ray examination of the chest July 28, 1914, disclosed: "Peculiar mottled dulness which appears most marked along lung margins and is scattered over the right chest and apices. Dense shadow about right hilus. Heart shadow is a little enlarged to the right. Picture is not typical of tuberculosis. May be syphilis of lungs." At this time he received three doses of salvarsan. The Wassermann was negative. During the next month he raised more bloody sputum, repeated examination of which showed no acid-fast organisms. Weight 139 pounds. Temperature 98.6°. After the fall of 1914, he was not seen again until his second admission to the Hospital in December, 1919. During this time he had no anti-syphilitic treatment. He had felt perfectly well until in October, 1919, when he was seized with a "terrible" pain in the right chest just below the nipple, worse on deep inspiration. It was diagnosed "broncho-pneumonia" by his local doctor. He was in bed ten days. For some time he had been having attacks of coughing lasting one-half to one hour in which he would raise about a half a tumbler of thick sputum, never blood-tinged or odorous. No chills, fever, or night-sweats. Physical examination of the chest gave the following facts: The left side was better developed below the clavicle than the right. The left lung was negative except for some compensatory emphysema. The right chest lagged in respiration. Below the third interspace in front and in the axilla were marked dulness and a considerable sense of resistance with diminished breathing and voice sounds. From the clavicle to the third interspace whisper, spoken voice and tactile fremitus were increased, breathing vesicular and a few fine moist râles on inspiration. The right back showed some dulness at apex increasing downward to almost flatness at base, bronchial breathing and increased whisper, spoken voice and tactile fremitus down the midscapula, below which there was diminished vesicular breathing. On cough, considerable medium moist râles were heard in the region of the spine of scapula, none at apex or base. Heart

examination disclosed nothing remarkable. All reflexes were negative. The chest consultant said: "Willing to rule out Tb. . . . Pulmonary lues the most probable diagnosis." Temperature 101.5°–100.5°. Wassermann negative. Sputum was repeated negative for tubercle bacilli, including an examination by the antiformin method. No spirochetes were found in the sputum. Urine negative. Blood: Hgb. 100 per cent (T). White count 19,600. Polys. 78 per cent. Lymphocytes 17 per cent. Large mononuclears 5 per cent. Reds normal. *X*-ray examination, December, 1919: "Entire right chest is dull. Dulness most dense at base, and outlines of the right diaphragm and the right border of the heart obliterated. In upper part of dull area there is a coarse mottled appearance, and there is a suggestion of retraction at apex. Heart is slightly drawn to the affected side. Left lung is relatively clear. Appearance is that of an extensive destructive process in or collapse of right lung and could be due to syphilis." Discharge diagnosis, syphilis of lungs. While in the ward he received one injection of diarsenol. Upon his return to the Out-Patient Department he stated that he felt much better. For a couple of months he continued to cough and again raised blood-streaked sputum in which repeated examinations disclosed no acid-fast bacilli. During the four months after discharge he received five injections of diarsenol and five of gray oil. On March 19, 1920, his weight was 130 pounds. Temperature 98.4°. He has not been seen since April 1920.

Discussion.—This, in brief, is a case observed over a period of approximately fourteen years following the appearance of secondary syphilitic lesions, during twelve of which he complained of pulmonary symptoms with occasional hemoptysis. Aside from the hemoptysis he presented none of the symptoms ordinarily associated with a progressive pulmonary tubercular infection, such as weakness, continued afternoon temperature, night-sweats and loss of weight. In the sputum, examined at intervals over a period of twelve years, acid-fast organisms were never demonstrated. There was very extensive development of the process on one side, leaving the other relatively clear, a condition very rarely seen in tuberculosis. Malignancy of the lung, of which hemoptysis may be an early symptom, is ruled out by the fact that the patient was alive twelve years following the first appearance of bloody sputum. The patient absented himself from treatment for two periods of four and five years respectively, returning both times because of renewed pulmonary symptoms and was improved both times by the resumption of antisyphilitic treatment. From the clinical point of view, the diagnosis of syphilis of the lung certainly seems reasonable.

The two plates in this case represent two stages of the gumma-with-peribronchitis type of picture. In Figure 2 there are coarse bronchial shadows with occasional small enlargements suggesting peribronchial gummata. Around the right hilus is the shadow of a larger gumma. In Figure 3 the process has progressed markedly on the right side. There has been extensive involvement of the pleura, cicatrization and retraction of the heart. In the upper part of the right lung field, coarse shadows of peribronchial infiltration and peribronchial gummata are seen. On the left there are diffuse, rather fine peribronchial shadows suggesting some fibrosis, but the lung as compared with the right is relatively clear.

Case III (Fig. 4). W. Female, white. Age forty-nine.

Came to the Out-Patient Department in October, 1915, with a series of ulcerating gummata of the skin of the right forearm. The Wassermann was strongly positive. Two months later she complained of marked dyspnea on exertion and pain in the region of the heart. There had been some cough for the preceding four to five months with scanty white sputum. No hemoptysis, fever, night-sweats or loss of weight. Physical examination disclosed dulness over the left side of the chest with broncho-vesicular breathing most marked in the axilla. Dry râles at the apex. Some moist râles on the

right side. The apex of the heart was felt 4 cm. outside the nipple. No murmurs were heard. Sent to *x*-ray with a question of syphilis of the lungs or tuberculosis. *X*-ray examination Feb. 11, 1916: "Left chest is dull throughout. Heart is displaced to the left. Right lung shows a diffuse thickening,

FIG. 4. CASE III. Left chest is dull throughout, obliterating the outlines of the diaphragm and left border of the heart. Marked retraction of the heart toward the affected side. Probable syphilitic bronchostenosis with collapse of the left lung. On the right there is diffuse peribronchial fibrosis, more marked in the lower than in the upper part of the lung.

otherwise negative. Picture is very suggestive of syphilis of the lung." The patient, who had been started on mercury and KI, did not return to the hospital after this date. Thus far attempts to trace her have been unavailing.

Discussion.—This is a case of tertiary syphilis with shortness of breath on exertion and cardialgia, without symptoms which ordinarily accompany chronic pulmonary disease, as fever, night-sweats or loss of weight, pointing rather to the heart than to the lungs. Examination, however, disclosed a practically functionless left lung and a diffuse fibrosis of the right. A tubercular involvement of that extent would in the great majority of cases have shown more on the right side and would have given some symptoms. A malignant involvement of that extent would probably have caused some loss of weight and other clinical evidences of malignancy. The diagnosis, of course, cannot be made definitely, but certainly pulmonary syphilis is strongly suggested. The plate shows two processes. On the left there is probably bronchostenosis with collapse of the lung. On the right there is a diffuse rather fine peribronchial fibrosis.

The writer wishes to express his appreciation of and gratitude for the kind counsel of his chief, Dr. George W. Holmes.

BIBLIOGRAPHY

1. OSLER. The Principles and Practice of Medicine. 8th ed., p. 272.
2. LORD, F. T. Diseases of the Bronchi, Lungs and Pleurae. p. 364.
3. CARRERA. A pathologic study of the lungs in 152 autopsy cases of syphilis. *Am. J. Syph.*, Jan. 1920, iv, 1.
4. Quoted by FUNK. Pulmonary syphilis. *Am. Rev. Tuberc.*, Feb. 1920, iii, 754.
5. POST. Two cases of syphilis of the lung. *Boston Med. & Surg. J.*, June 15, 1916, clxxiv, 876.
6. WATKINS. *X*-Ray characteristics of lung syphilis. *J. Radiol.*, May, 1920, i, 297.
7. Quoted by CARRERA, *loc. cit.*
8. HAMMAN. Diseases of the lungs. *Oxford Med.*, ii, 108.
9. SCHUPFER. Pleurisy and peritonitis in the syphilitic. *Riforma Med.*, xxxvii, 25, Abst. *J. Am. M. Assn.*, March 19, 1921, lxxvi, 825.
10. NODAL. Pleuro-pulmonary and mediastinal sclerosis in children and congenital syphilis. *Thèse de Paris*, 1919. Abst. *Am. J. Syph.*, 1920, iv, 176
11. DUNHAM. Stereoroentgenography: Pulmonary Tuberculosis, p. 73, Stereo 36.
12. CHRISTIE. The diagnosis of primary tumors of the lung. AM. J. ROENTGENOL., March, 1921, viii, 97.
13. BRADFORD. Massive collapse of the lung. *Oxford Med.*, ii, 127.

FRACTURES OF THE PELVIS*

By C. C. GRANDY, M.D.

FORT WAYNE, INDIANA

I WAS prompted to look up fractures of the pelvis because we have four cases in the hospital now.

Fractures of the pelvis are acquired by direct violence or force, such as railroad and automobile accidents and falling from heights. They are usually classified as minor and major fractures.

Symptoms depend on the kind of fracture, whether it is minor or major, and what portion of the pelvis it involves. Owing to the peculiar shape of the pelvis and the many different muscles attached to it, it is hard to mention all the symptoms. But symptoms are not reliable, as one of the patients was able to walk into the laboratory, and it was only because the insurance company asked for a roentgen examination of the pelvis that the fracture was found. Minor fractures are usually without complications while major fractures are frequently complicated.

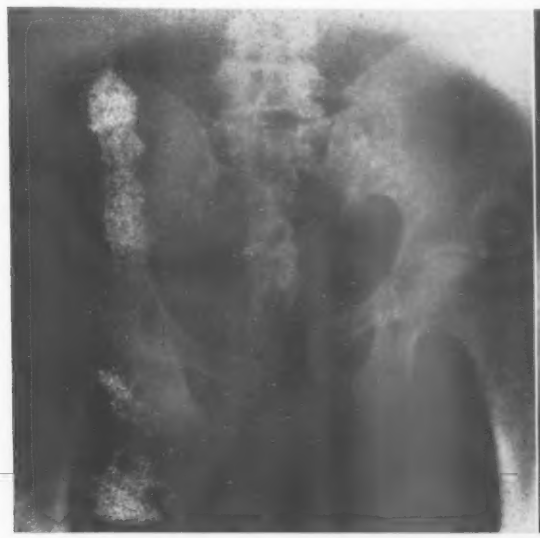


FIG. 1. CASE 1. Male, age forty, fell down elevator shaft, four stories. Fracture of pubes. He had no complications of any sort.

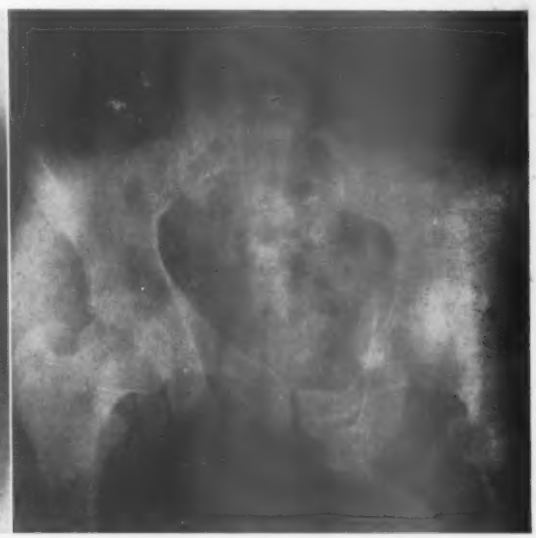


FIG. 2. CASE 2. Male, age twenty-seven. Fracture of pubes, both sides. He came walking into the hospital. Had no complications of any sort.

Minor fractures are those that involve:

(1) Upper expanded portion of the ilium.

(2) Rim of acetabulum.

(3) Ischial tuberosity.

(4) Coccyx and tip of sacrum.

Major fractures are:

(1) Separation of the symphysis pubis.

(2) Fracture of the pubic and ischiopubic rami.

(3) Fracture in the region of the acetabulum.

(4) Separation of the sacroiliac joint.

(5) Transverse fracture of the sacrum, or that portion of the pelvis that enters into the pelvic girdle.

The complications of fractures of the pelvis are only a few, but they are very serious, depending upon the location of the fracture. The most common complications are:

(1) Ruptures of the membranous urethra.

(2) Laceration—bladder.

(3) Injury to large blood vessels.

(4) Injury to sacrococcygeal nerves.

Rupture of membranous urethra is due to a tear in the triangular ligament. Rupture of

*Read at the Second Annual Meeting of the Central Section THE AMERICAN ROENTGEN RAY SOCIETY, St. Louis, Mo., Feb. 21, 1921.

the bladder and injury to the blood vessels, especially the external iliac arteries, are usually due to some sharp spicules of bone.

FIG. 3. CASE 3. Female, age thirty-eight. She was thrown from a motor and struck on her hip, fracturing both pubes; had no complications.

Out of the series of seven cases there were three with ruptured urethra and one with laceration of bladder, and all of them developed urinary abscesses. One died from hemorrhage and shock from a lacerated external iliac artery with a dissecting extravasation of blood under the entire peritoneum.

A point that I want to bring out in these few illustrations is that one cannot tell from the roentgenograms whether the membranous urethra or bladder has been injured, and if at all suspicious one should advise the passing of the catheter.

CASE 1. Male, age forty, fell down an elevator shaft a distance of four stories. Sustained a fracture of the symphysis, a fracture through the right sacroiliac joint and a fracture of the lower third of both bones in both legs. He had no complications with his pelvic fractures.

CASE 2. Male, age twenty-seven, fell from a bridge two weeks before this examination was made and walked into the hospital. He has a fracture of the ascending and descending rami of pubes. No complictions.

FIG. 4. CASE 4. Fireman thrown from fire truck. Fracture through pubes and symphysis, ruptured urethra and multiple abscesses.

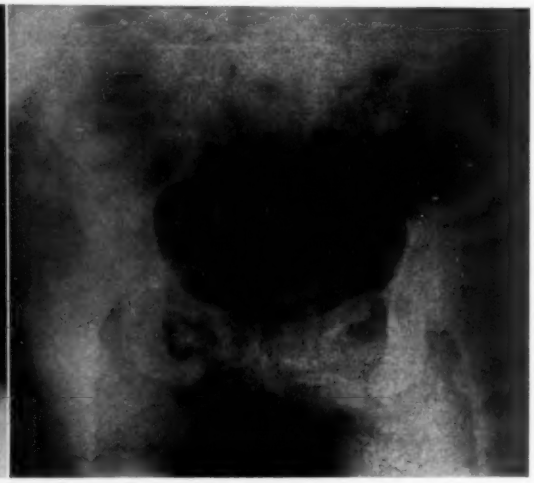


FIG. 5. CASE 5. Female, age twenty-eight, hurt in interurban wreck. Fracture of both sides of pubes. This happened to be complicated by a urinary abscess.

CASE 3. Female, age thirty-eight. She was thrown from a sleigh and struck her hips. Fractured both ascending and descending rami on both sides of the pubes. There were no complications.

CASE 4. Male, age forty-eight, fireman. He was thrown from a fire truck while turning a corner and sustained a fracture through the symphysis and the left sacroiliac joint. Complicating this was a rupture of the membranous urethra with many pockets of extravasated urine scattered throughout the perineum and down both thighs.

FIG. 6. CASE 6. Woman struck by an automobile. Fractured both sides of the symphysis. Died three hours later.

CASE 5. Female, age twenty-eight. This patient was in an interurban wreck and fractured both the ascending and descending rami of the pubes. She has a rupture of the urethra and many urinary abscesses; one abscess was opened in the popliteal space.

CASE 6. Female, age fifty. This patient was struck by an automobile and had a fracture of both sides of the symphysis. She was very profoundly shocked when brought into the hospital and died three hours later.

Postmortem revealed that the left deep epigastric artery was torn with a large hemorrhage which had dissected underneath the peritoneum almost all the way around the abdomen and up to the diaphragm.

CASE 7. Female, age seven. This little girl was struck by an automobile and sustained a fracture of the symphysis and the wing of the ilium through the acetabulum. She passed a small amount of blood in the urine the first twenty-four hours but this cleared up and there were no other complications.

FIG. 7. CASE 7. Little girl struck by automobile. Fracture of symphysis, wing of ilium through acetabulum.

DISCUSSION.—Most of the cases that were complicated came into the hospital several days after their injury. The urinary abscesses were drained and a catheter passed from below, if possible; if not, we would operate through the perineum and pick up the torn ends of the urethra and unite them around a retention catheter and wait until a new urethra had formed.

TWO CASES OF LYMPHATIC DISEASE IN THE SAME FAMILY, WITH ROENTGEN FINDINGS*

By CHARLES M. RICHARDS, M.D.

SAN JOSE, CALIFORNIA

THE justification for reporting these two cases at this time lies not so much in the intrinsic interest of each case separately, though indeed this was not small, but in the occurrence of two supposedly allied conditions in the same family. The rarity of this occurrence may well place it in the category of coincidence. On the other hand, it may be of some interest and value to the clinician who is trying to work out a logical interrelationship between the various lymphatic new growths, particularly in respect to their etiology. Very little of the available literature makes mention of the occurrence of these allied conditions in families, and then only to mention its rarity.

From the roentgenological standpoint, they are of interest, particularly the latter case, as illustrating the value of the new diagnostic procedure of peritoneal inflation.

CASE I. The first case came under my notice in April, 1915, being referred by Dr. J. I. Beattie for roentgen examination of the chest of a young woman about sixteen years of age, whose previous history had been negative except for the fact that one year previous to this time she had had an enlargement of the anterior cervical glands, which was diagnosed as tubercular adenitis. She was given a course of tuberculin treatment, and while the glands subsided somewhat, they did not entirely disappear, and were still present when the patient was seen at this time. About three months previous to this examination she had begun to suffer with marked dispnea, which had been constantly increasing, attended by a persistent cough. She had also begun to complain of a severe pain of an anginal character in the chest which radiated into the back and into the arms, particularly the left. There were occasional chills, with a moderate rise in temperature and rapid pulse. The patient was first seen for this complaint about April 8, 1915, and was seen by Dr. N. H. Bullock in consultation a few days later. At this examination she was found to be running a slight temperature, around 101°, with distinct evidence of consolidation in the mediastinum and left upper thorax, and signs of fluid in the left chest. The left chest was aspirated

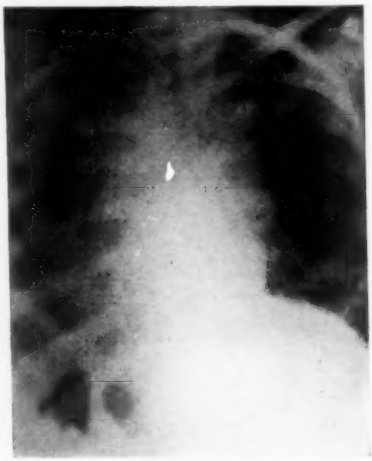


FIG. 1. CASE I. Mediastinal lymphosarcoma.

and sixteen ounces of bloody serum withdrawn. This was examined for tubercle bacilli, which were not found. The patient grew gradually worse; pain, dyspnea and cough becoming very severe, and she lost ground rapidly. She was removed to the Columbia Hospital, and a roentgen examination was made which revealed a large mediastinal tumor extending well up into the left upper chest and also less extensively beyond the right root region.

Here a confusing element entered, for a blood count had revealed a leukocytosis of about 24,000, with a large percentage of polynuclears. On the strength of this blood count a diagnosis was made of a probable mediastinal abscess. Dr. Emmet Rixford, of

*Read at the summer meeting of the Pacific Coast Roentgen Ray Society, Catalina Island, California, June 17-19, 1920.

San Francisco, saw the case in consultation, and on April 26 he and Dr. Beattie operated, and came upon a large solid tumor mass within the left chest which was diagnosed clinically as lymphosarcoma, and the pathological examination of a small gland removed at the time confirmed the diagnosis. The patient failed rapidly and died on May 1st.

CASE II. A Bohemian, age seventy-five, a merchant, was admitted to the Santa Clara County Hospital about January 20, 1920. The family history was negative except that a daughter had died of a "tumor in the chest" about five years before. The past history was negative. The present illness began about nine months ago, when he said he strained himself lifting a heavy object, and injured the left ribs. There followed pain in the lower left ribs and lumbar region. This improved and grew worse at times. Four weeks previously he spat up some blood and now has occasional epistaxis. Since the strain, as he called it, he has not been entirely free from pain in his left side, and has considerable dyspnea on slight exertion. Physical examination revealed an anemic old man, somewhat emaciated. Pupils equal and reacted to light and accommodation. The cervical glands were all enlarged.

The blood-vessels of the neck and upper thorax were distended. There was an extreme tenderness from the ninth to the eleventh ribs in the left axillary region; the same less marked on the right side. There was bulging of the costal angle on the left, and the entire left chest appeared more prominent than the right, and lagged on respiration. The breath sounds were harsh all over the chest with a few friction sounds at the left base. Heart examination was negative. There was slight arteriosclerosis.

The examination of the abdomen revealed the liver palpable at the costal margin and in the epigastrium. The border of the spleen was felt as a firm sharp edge reaching almost down to the umbilicus. The lower abdomen was distended apparently by a full bladder, and the superficial veins were also enlarged. The back was held rigid when he moved and there was some scoliosis. The knee jerks were slightly increased.

Several examinations of the urine revealed occasional presence of considerable amount of blood. Blood examination of January 25th showed: hemoglobin 65 per cent, red cells 3,984,000, white cells 142,600, of which 97 per cent were lymphocytes. On February 17th the hemoglobin was 50 per cent, the red

FIG. 2. CASE II. Lymphatic leukemia.

cells 3,256,000, white cells 112,000, of which 95 per cent were lymphocytes. On April 17th the blood showed: hemoglobin 60 per cent, red cells 2,816,000, white cells 41,400, of which 96 per cent were lymphocytes. The Wassermann reaction was negative.

On January 24th I made a roentgen examination of the chest and inflated the peritoneum with oxygen after the method of Stewart and Stein. The chest showed a dense infiltration of the glands of both roots, with lymphatic extension in all directions from the roots into both chests. The abdomen showed an immensely enlarged spleen, the notch being plainly visible in the roentgenogram, and in the liver shadow several denser areas which were taken to be patches of lymphatic tissue within the liver.

An interesting feature in this case was the

decided improvement in symptoms and in the blood picture, following the oxygen injection. So much better did the patient feel that he insisted upon a repetition of the procedure about a week later. This phenomenon has been observed by other authors in certain blood diseases. The chief observation to be made on these two cases is in reference to the interrelationship of the two diseases with the addition of the third member of the group, lymphadenoma or Hodgkin's disease. The occurrence of these two lymphatic overgrowths in a single family would perhaps suggest a little closer relationship even than has been supposed to exist, and if the presentation of these two cases has added a morsel of evidence for those clinicians who are interested in this work the justification for their publication is ample.

I am indebted to Drs. Beattie and Bullock and to Dr. D. R. Wilson for the clinical notes on these cases.

GASTROCOLIC FISTULA*

With a Report of a Case

By L. B. GROESCHEL, M.D.

Roentgenologist, New York Diagnostic Clinics

NEW YORK CITY

GASTROCOLIC fistula is not a rare condition, but that it is infrequently diagnosed is evidenced by the lack of cases reported in the literature. Burnham, in an excellent article on this subject, reports two cases, and in a review of the literature states that Zweig found but 70 cases reported, only 11 of which had been diagnosed during life. Voorhoeve found 105 reported up to 1912. Single cases have been reported by various others. It is thus noted that the clinical diagnosis of this condition is not common.

In the case I am reporting the diagnosis was made by the roentgen ray following the injection of a barium-mucilage-of-acacia enema and demonstrated both by the fluoroscope and the plate. The patient, male, age forty-eight, was referred by Dr. Harry Goldman.

Family History.— Married twenty-one years, three children, wife in good health, otherwise negative.

Past History.—Typhoid at sixteen years; sick six weeks.

Present History.—For the past eighteen years patient has been having trouble with his stomach; indigestion, heartburn, pain two hours p.c., constipation and headache. Pain at first was in epigastrium, and then throughout the entire abdomen. This continued for a long time without improvement until nine years ago, when he had his appendix removed and gall-bladder drained. No stones were found. In 1912 a second operation was performed. A gastro-enterostomy was done and gall-bladder removed. No ulcer of the stomach or duodenum was found. For one year the patient felt relieved as to his pain, but soon afterward the same trouble began again, except that the pain became localized in the gall-bladder area, radiating towards the back and right shoulder. The patient formerly had an attack once every few months, but lately has had attacks about every two weeks, such attacks lasting three or four days and accompanied by sharp pains, belching, nausea (but no vomiting) and headache. He noticed that for two or three days following the stools were completely white and the urine quite dark. Stools were not fatty and only occasionally were they bulky. During the last two years the patient has been accustomed to wash his stomach after an attack with considerable relief. He sleeps well, but lately

*Thesis presented with application for membership in The American Roentgen Ray Society.

is awakened by pain and obtains relief by a hot water bag and a *change of position.* He has lost twelve pounds in the last two years.

A test meal consisting of two slices of bread and a glass of water one and a half hours p.c. showed the following:

Examination by Dr. Kunstler

Amount received	80 c.c.
Color	brown
Odor	fecal
Mucus	2 plus
Occult blood	0
Free HCl	70
Total acidity	100
Starch cells	Few
Pus	0
Blood	0
Boas-Oppler	0
Necrotic tissue	0
Remarks	Feces in contents

Examination of Feces (Dr. Turck)

Color	Grayish white
Consistency	thin
Reaction	faintly acid
Bile	very faint trace
Occult blood	very faint trace
Mucus	0
Undigested vegetable fibers	few
Undigested muscle fibers	few
Pus cells	0
Blood cells	0
Fat	marked amount
Parasites	0
Ova	0
Remarks	Many fatty acid crystals

Urinalysis was practically negative. No bile was noted. Indican was normal. Albumin and sugar were negative.

The gastro-enterological report (Dr. Kunstler) is as follows: "Gastro-enterological examination reveals a very marked hyperacidity with a gastric retention and a regurgitation of feces. The case appears to be one of obstruction of the colon or an opening from the stomach into the colon, possibly from an old operative interference."

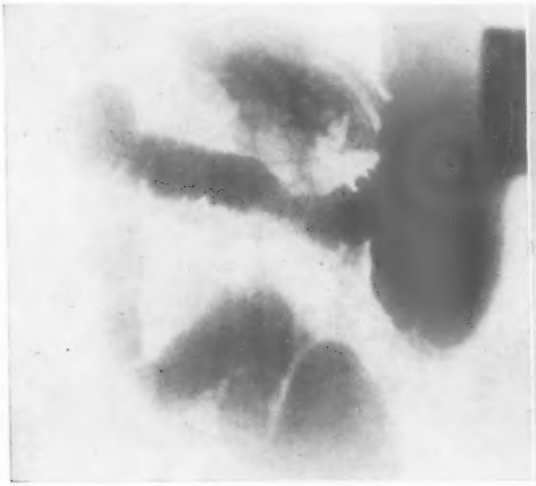


FIG. 1. October 30, 1919. After colon enema. Stomach beginning to fill.

FIG. 2. October 30, 1919. After colon enema. Stomach partly filled.

Roentgen examination was conducted on October 30, 1919. The patient was given a barium-buttermilk meal of sixteen ounces in the erect position and fluoroscoped. The stomach filled normally. Peristalsis was very active. The antrum and first portion of the duodenum lay four inches to the right of the median line and adherent to the under surface of the liver. No defect in the lesser curvature was noted. The duodenal cap filled normally without defect and was fixed by adhesions.

On the posterior wall near the middle line of the antrum and about one inch from the border of the greater curvature there was

FIG. 3. October 30, 1919. Lateral view showing gastro-enterostomy.

FIG. 4. October 30, 1919. Anterior-posterior view, showing gastro-enterostomy.

noted a large, patent gastro-enterostomy opening through which the meal was passing rapidly. Just below the gut widened into a large pouch-like dilatation holding approximately four ounces. Anteriorly to the gastro-enterostomy opening (as noted in the lateral position) and extending along the greater curvature for several inches the gastric wall assumed a moth-eaten appearance.

Six-hour examination showed a slight residue of about an ounce in the stomach and the remaining portion of the meal in the terminal ileum and ascending colon. Twenty-four-hour examination showed the stomach and small intestines empty. A slight amount of the meal had been evacuated and the remainder filled the colon. The hepatic flexure lay in a normal position but was fixed by adhesions. The transverse colon passed, transversely, across the abdomen from just above the crest of the right ilium to the splenic flexure which was in a normal position. No fistulous tract was noted.

A barium colon enema was then given (after a preliminary cleansing enema) and observed fluoroscopically during the administration. The rectum, sigmoid, descending and transverse colon filled normally, but the ascending colon and cecum ballooned out to

FIG. 5. October 30, 1919. Anterior-posterior view, showing gastro-enterostomy.

practically twice the size. At the same time a quantity of the barium mixture was observed spreading out through the gastric area and assuming the gastric shape and

appearance of rugae. A plate was made immediately which confirmed this observation. The opening from the colon to the stomach

FIG. 6. October 31, 1919. Twenty-four hour plate.

could not be made out. The barium now in the stomach was a few minutes later noted passing out again through the gastro-enterostomy opening.

Three days later, after a thorough catharsis and preliminary cleansing enema, the barium enema was repeated with the same result, with the exception that the gastric area filled more fully in the region of the splenic flexure. A diagnosis of gastrocolic fistula was made.

SUBSEQUENT REPORT

Several weeks after this examination the patient went to the Mayo Clinic for confirmation and observation. During this time he had no recurrence of his gastric symptoms. He felt exceptionally well and gained a pound and a half. He was rayed there twice at intervals of about a week, and no abnormal condition was found (Report of Dr. Eustermann).

The patient returned to New York City and felt very well until about the last week in February, 1920, when he had a sudden fainting spell one evening, followed by a return of all previously noted symptoms.

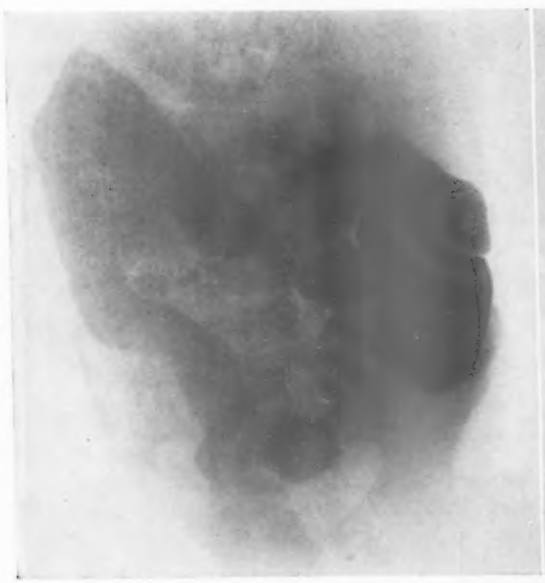


FIG. 7. March 4, 1920. Ten minutes after barium enema. Small amount of mixture in stomach.

FIG. 8. March 4, 1920. Fifteen minutes after barium enema. Stomach filled. Second half of transverse colon and ascending colon empty.

He was returned to me for radiographic examination. The report at this time (March 4, 1920) is as follows:

"The patient's colon (barium enema) shows, under the fluoroscopic examination during the administration, the mixture passing freely throughout without obstruction and filling out the hepatic flexure, ascending colon and cecum. Observation over a period of five minutes did not show any of the barium mixture passing into the stomach. Five minutes later a plate was made to illustrate this condition, and developed immediately, when it was noted that there was a constriction about the middle of the colon opposite the site of the gastro-enterostomy opening and that there was a small amount of bismuth in the stomach. The ileocecal valve was competent and there was no regurgitation of the barium mixture backward through this opening, excluding the possibility of the enema passing backward through the small intestines. There was noted a small amount of the mixture passing from the stomach through the gastro-enterostomy opening. Five minutes later a second plate was made which showed the ascending colon and the first half of the transverse colon, up to previously noted constriction, empty, and the stomach filled with barium mixture."

THE ROENTGEN RAY TREATMENT OF THE ECZEMA GROUP

By F. J. EICHENLAUB, M.D.

Instructor in Dermatology and Syphilology, Georgetown University Medical School, and Howard University Medical School

WASHINGTON, D. C.

THIS study is an effort to obtain statistically the approximate efficiency of the roentgen ray in the treatment of the class of dermatoses which in the past we have called eczema.

One hundred cases falling under this general category were selected from the files in the office of Dr. H. H. Hazen and myself, the only consideration being that the chief reliance in treatment had been the *x*-ray and that the cases, all private, were followed sufficiently long to draw conclusions. Nine of these cases were clear-cut neurodermatitis, recently reviewed by Wise.[1] In all of these nine a clear history of mental stress had preceded the outbreak. In several there had been a number of attacks following mental stress. All presented typical lichenifications at the flexors of the elbows and knees, back of the neck, etc. This is an undoubted clinical entity, but in the past it has been called eczema, and is still so regarded by many men.[2] The other 91 cases ranged from small patches of dermatitis on the hands due to external irritation to extensive cases of generalized eczema, probably chiefly due to internal factors—soap dermatitis, primrose dermatitis, irritation from various trades, urticarial eczema, etc.

Treatment consisted in the administration of approximately one-half H skin units every two weeks over all affected areas. Our technique was 4 milliamperes, 7½ inch spark gap, 9 inch focal skin distance, 35 seconds for each application. In exceptional cases slightly smaller doses were administered every ten days. The number of treatments required to clear up the condition varied greatly, and had little relation to the duration of the disease in many cases. A patch that had been present only a few weeks might require many months to cure, recurrence occurring time after time when the disease seemed conquered; while others that had been present for years cleared up with two or three applications of the ray.

[1] Wise. *Jour. Cut. Dis.*, 1919, xxxvii, 590.

[2] See discussion of Wise's paper.

The cause, whether internal or external, played little part in the result of treatment. In general, the results were better with *x*-ray treatments than by any previously known method of attack, and while no effort is made to check the results in this study by comparison with cases not *x*-rayed, this fact was easily demonstrated many times. Frequently, to convince the patient or ourselves as to the effectiveness of the ray in a given case, we have treated only a part of the affected skin with the *x*-ray. Ten days later our patient has returned with the part so treated from 50 to 100 per cent better than the parts treated by other methods of internal or external dosage with drugs. In this series of 100 cases the average number of treatments per case was about three.

TABLE

Number of Cases	*Average number of treatments*	*Average duration of disease*	*Average time to cure*	*Failures*
100	2.93	135.50 weeks	7.64 weeks	4

The duration and time to cure is stated in weeks to facilitate comparison.

The duration of the attack varied from two weeks to twenty years. In many of the cases where a long duration is noted there were periods of complete or partial freedom from the disease. For the most part, however, the patients were never entirely free. One case, for instance, a trade dermatitis, had been present for ten years or more without a single interval of freedom and without ever having been affected by treatment to any extent. After six *x*-ray applications he has been entirely free for over a year, although he has pursued his occupation of hospital orderly, and has not changed his mode of life in any way. This is unusual, however. We have generally depended on the *x*-ray to cure the patient. Recurrence has been prevented by finding the cause, and stopping it if possible.

A case is considered cured when objective symptoms have entirely disappeared for several months, and have failed to reappear within the usual time of recurrence for that particular case when more than one attack had been present. In estimating the time to effect this cure and the number of treatments given, the entire period, including relapses, in which the patient was under our care was included. This acts as a balance to the duration where this term included a number of attacks with periods of freedom. The average time to cure, within the meaning of that word as here defined, was approximately two months.

Out of 100 cases there were 4 per cent failures. We considered cases as failures which did not respond at all or were only partially benefited. There were only four cases, therefore, which did not entirely clear up under treatment. In two of these we failed entirely, the other two received only temporary benefit. This percentage of cures is probably higher than actually obtained, as a few cases were not included in the study which disappeared after the first visit, because, perhaps, they became discouraged at not getting immediate results. We cannot say whether or not they could have been cured.

CONCLUSIONS

1. One hundred cases of eczema with an average duration of over two years took an average of two months and three treatments to cure.

2. Four per cent of the cases were failures.

3. The superiority of the *x*-ray over other forms of treatment is believed to be demonstrated for this group, and its routine use justified.

SOME REMARKS ON THE PRESENT STATUS OF X-RAY THERAPEUTICS*

By GEORGE W. HOLMES, M.D.

Roentgenologist of Massachusetts General Hospital; Instructor of Roentgenology, Harvard Medical School

BOSTON, MASSACHUSETTS

ROENTGENOLOGY and radiotherapeutics are comparatively recent terms in medicine. There are members of this Society present who have been active workers in and contributors to this science since its very beginning. It is, therefore, unnecessary for me—even if it were possible in the time at my disposal—to attempt anything like a review of the literature, or to call to your attention the names of those men whose work has placed this method of treatment on its present sound basis.

I shall, therefore, confine my remarks to a brief outline of the steps in advance which seem to me most important, and to a discussion of the principles underlying the successful treatment of disease by the roentgen ray, particularly of the results obtained in this country.

In a review of this subject, one is of necessity impressed with the failure to increase to any great extent the number of cures obtained over those of ten or twelve years ago, although during this period great improvement has been made in the apparatus placed at our disposal, and although in the fields of physics and biology discoveries of far-reaching importance have been made.

During this period the attitude of the general medical profession towards our specialty has shown a great change for the better. Ten years ago skepticism was the rule; now we are receiving the benefits of the careful work done and the conservative attitude taken by the early teachers, and opportunity for work in this field is almost unlimited.

In 1907, the American Roentgen Ray Society published in book form the proceedings of their annual meeting held in Cincinnati. Papers were read at this meeting by Pfahler, Pancoast, Johnston, Williams and others, giving the results obtained and the technique used in the treatment of carcinoma, sarcoma—the so-called blood disease, and the disease of the ductless gland. The results which were recorded in their papers compare quite favorably with those being obtained to-day, nor has there been any great change in the method of application, other than that which would naturally come with improvement of apparatus.

Why has the radiotherapeutist failed to keep step with his co-workers, the physicist and the biologist? Surely it is not because of lack of material, but rather, I think, because those men who from their knowledge and experience could have advanced the science have been overwhelmed with routine work, and have not been able to surround themselves with student workers who could carry out their ideas, as have the advanced workers in other fields.

That the Society as a whole is alive to this condition is shown by its action at the meeting in Minneapolis this year, when it was voted to establish the Caldwell lecture and the Leonard prize fund for original research. It is because of the absence of the purely research workers in our large clinical laboratories, I believe, that we have not advanced as rapidly as our colleagues. If the next ten years are not to be a repetition of the past, some individual effort must be made to remedy this evil.

Almost from the beginning, original research in this field has been directed along four distinct lines:

1. Method to determine the amount of radiation used.

2. Method for determining the quality of radiation, and the selection of different qualities for different diseases and conditions.

3. The effect of radiation upon normal and pathological tissue.

*Read before the New York Roentgen Ray Society on the Twenty-fifth Anniversary of the Discovery of X-Rays, New York Dec. 11, 1920.

4. The effect of treatment upon the individual as a whole and his reaction to it.

Let us consider briefly what has been accomplished under these four headings.

Method to Determine the Amount of Radation Used.—The measure of dosage has been determined with considerable success in two ways:

(1) The direct, by measurement of the amount of radiation reaching the tissues being treated.

(2) The indirect, by measurement of the amount of electrical energy supplied to the tube, and from this computing the amount of energy in the form of radiation coming from it.

The pastille, first introduced by Sobround, and later elaborated by Holzknecht and Hampson, is an example of the first method, and for a considerable time it was the most accurate method available. There are difficulties in their use, however:

(1) They depend upon a color change, and this change is very slight. Errors of as much as 50 per cent may result from this source alone.

(2) Their rate of change varies with different qualities of radiation, long waves affecting them to a relatively greater extent than short ones.

(3) They deteriorate and become inaccurate unless kept in an atmosphere containing the proper amount of moisture. Even in the hands of the most careful and well trained men, it is probable that errors of 20 to 50 per cent occur.

Kienboeck substituted strips of photographic paper for the pastille. This eliminated the errors due to changes in the quality of rays used, but is a cumbersome and difficult method, and was never very popular in this country.

The indirect method of measurement is largely an American achievement and was made possible by the development of the interrupterless type of transformer by Snook and the hot cathode tube by Coolidge, even before the introduction of the Coolidge tube.

Sewell Cabot developed an interrupterless transformer with which it was possible to estimate with considerable accuracy the radiation from a gas tube; and in 1914, I published in the JOURNAL of this Society a table of dosage based on the amount of electrical energy supplied to the tube when using a Cabot machine.

The Coolidge tube has greatly simplified this method of measurement, and the work of MacKee, Shearer and others has caused the indirect method to be generally adopted throughout America. It has the advantage of convenience, and is probably more accurate than pastille or paper, but is by no means entirely satisfactory. The table of dosage used with one machine cannot always be used with another, particularly if the wave form is different. The voltage is still a difficult factor to determine, and the amount of radiant energy coming from a tube does not depend entirely upon the amount of electrical energy supplied to it.

A method of direct measurement which has not yet come into general use, but which seems to offer considerable promise, is the ionization chamber adapted for practical work. With this instrument it is possible to measure with considerable accuracy not only the amount of radiation reaching the part being treated, but by placing a second chamber below, the amount actually absorbed can be measured.

Method for Determining the Quality of Radiation, and the Selection of Different Qualities for Different Diseases and Conditions.—Although it has been shown experimentally, at least, that the effect of radiation does not depend upon kind, but upon quantity of rays absorbed, it is still necessary to use rays of a certain quality to obtain the maximum effect at different levels below the surface.

Many of the early writers recommend the use of the "hard tube" in the treatment of deep-seated lesions, and in 1905, Pfahler adopted the use of filters to shut out the soft rays.

The more recent work of the Braggs has made it possible to analyze *x*-radiation, and to formulate laws governing their production and absorption. But as yet no practical

method has been devised for using rays of a single wave length in the treatment of disease. Until this can be done, some of us who have seen metastatic nodules in the skin which persisted through a full course of treatment with filtered radiation disappear rapidly when unfiltered rays were used, will doubt the statement that quantity and not quality is of supreme importance.

There is a tendency at the present time to use rays of shorter and shorter wave length, and it is quite possible that we are reaching a point where the rays used may pass to a large extent through the diseased tissue and produce unnecessary injurious effects upon the underlying organs. The very short wave lengths have been used in an effort to save the overlying tissues; perhaps more reliance should be placed upon cross firing and upon increasing the target skin distance. The value of distance in equalizing the dose throughout a given mass of tissue is well known and is explained by the inverse square law.

During the past year I have used a 16 inch target skin distance where I was especially anxious to avoid an erythema or where the mass treated was unduly large or deep, and I am sure that my results have been better than with the standard 8 inch distance. The Huntington Hospital of Boston is planning to use a 24 inch distance. I am aware that there is nothing new in this suggestion, but I believe that it is not sufficiently well recognized in this country.

The Effect of Radiation upon Normal and Pathological Tissue.—Dr. Robert B. Greenough, in July of this year, read a paper before the International Society of Surgeons, in which he discusses at considerable length the biological and therapeutic effects to be expected from treatment with *x*-rays or radium. He sums up the present knowledge of this subject as follows:

1. Living tissue may be destroyed *en masse*.
2. Growth may be temporarily inhibited.
3. Rapidity of growth may be stimulated.
4. The manner of growth may be modified.

And he further states that in the terms of these four phenomena, we must consider the action of radiation in the treatment of disease.

There seems to be ample support for Greenough's conclusions. His statements are based on the results of laboratory experiments conducted by physicists and biologists, both in this country and abroad. They are also borne out to a considerable extent by clinical observations. He believes that in the treatment of malignant disease, in order to produce a cure, all of the malignant tissue must be destroyed, and that mass destruction is the only way to bring about this result.

If we grant this hypothesis, there can be very little if any possible advantage in treatment by radiation over that of surgery, a possible exception being those superficial lesions occurring in positions where scar formation is to be avoided.

There is, however, I believe, an equally good theory, namely, that malignant disease may be destroyed by stimulation of the connective tissue around it, in this way shutting off its blood supply and arresting development. Nearly every pathologist who has studied the effect of radiation has noted that connective tissue changes are the earliest to appear, and that they are a characteristic finding in tissue which has been under prolonged radiation.

Dr. Wolbach of the Harvard Medical School is an advocate of this theory. Dr. Martin, working with Dr. Wolbach, made some experiments on rabbits which to some extent confirmed this theory.

Another possibility of the cause of cell destruction by radiation is that some antibody or ferment is produced in the blood or tissues which has a destructive or inhibiting action on tumor cells. Dr. Crane suggested such a possibility in 1907, and there is a large amount of experimental and clinical data which seems to confirm such a theory.

That radiation is capable of inhibiting growth can be demonstrated by observing its effect upon individual cells.

If a mononuclear organism, such as paramecium, be exposed to a sufficient amount of

x-radiation, cell division ceases; but if the dose is not sufficient to kill the organism, and the animal is not exposed to repeated doses, it will soon begin to divide and the rate of division will be considerably increased, so that in a short period of time the rayed animal will have divided as many times as an unexposed organism used as a control.

This power of inhibiting cell division and of maintaining it for considerable periods of time, is of practical importance to us in treatment, particularly in treating a glandular disease, such as hyperthyroidism. It may not be necessary to destroy with massive doses the structure of the thyroid gland, but by giving a relatively small dose at rather frequent intervals, we may inhibit its function and maintain it until the vicious circle has been broken and the individual recovers from the disease. In the treatment of deep-seated malignant disease, where it is not possible to destroy all of the pathological tissue, radiation should be sufficiently frequent to maintain this inhibiting power.

Modification of Cell Growth by Radiation.—In addition to its destructive, inhibiting and stimulating powers, the action of radiation on organisms tends to modify and influence its growth. Irregularities take place, and changes in the shape and characteristics of the cells have been noted. When frog's eggs are rayed, monstrosities will appear among the tadpoles. This has also been demonstrated when using the eggs of fowls. When pregnant guinea pigs and rabbits are subjected to heavy raying, similar monstrosities have been produced. Recently a case was reported in which an abnormality of this kind appeared in the human fetus, where the mother had been treated for fibroids. Attemps to stimulate normal cells by radiation until they take on malignant form has, however, so far been unsuccessful. In applying radiation should be sufficiently frequent to therefore justified in hoping that the modification will be a beneficial one.

The Effect of Treatment upon the Individual as a Whole, and His Reaction to it.—That prolonged or extensive radiation may have a profound effect upon the individual as a whole is well known, perhaps the most striking evidence being the so-called treatment sickness, the exact cause of which is unknown. One of the early theories advanced was that this sickness was caused by inhalation of gases produced by the high potential discharge. Pfahler was able to diminish somewhat the amount of sickness occurring in his patients by better ventilation in the treatment room, but this theory does not fully account for the condition, as similar symptoms have occurred after heavy exposure to radium. Lang suggested the possibility of acidosis and recommended the use of sodium bicarbonate. More recent studies of the blood, particularly of the blood nitrogen, indicate that the acidity is somewhat raised after radiation, and that this is due to an increase in the hydrogen ion content. Much more work will be necessary before one can make any definite statements as to the cause of treatment sickness. Probably there are several factors entering into it, the most active of which is due to some obscure change in the blood.

Other evidence which we have of the general effect of radiation is the improvement in the general well-being of the patient. This is apparently brought about to a considerable extent by an increase of metabolism. That the metabolic rate is increased has been shown by studies on individual cells and by basal-metabolism tests of individuals undergoing treatment.

Other evidence which should not, perhaps, be classed as affecting the organism as a whole, but in which the effect is not entirely local, are such findings as the disappearance of glands at a distance from the part rayed, a frequent occurrence in Hodgkin's disease. Knox observes that patients with malignant disease who have a fairly good color index respond much better to radiation than those in whom the red count is low, and he attributes this to the better opportunity for the production of secondary radiation from the hemoglobin in the blood in cases with a high or normal red count.

Smith and Clapps have injected the blood of a patient suffering from leukemia who

had previously derived benefit from *x*-ray treatment into unrayed patients suffering from the same disease. This procedure produced a decided drop in the white count in the blood of the patients so treated, whereas the injection of normal blood or blood from untreated leukemia patients caused a raise in the count.

In a recent discussion of this subject with Dr. George Minot he stated that he had observed that the glutinating properties of the blood are diminished after radiation, that is, the blood of patients who have had typhoid fever loses to a considerable extent its power of causing clumping of the typhoid bacillus.

A theory has been advanced that the activity of radiation on tissues is due to the action of enzymes, and that the ionization of the tissues by changing the acidity of the tissue juices stimulates or depresses these enzymes. The literature on this subject was carefully reviewed, and some additional original work presented by Richards in 1914.

All this data, which has been accumulated in the laboratories, is of importance in the treatment of the patients who come to us for relief, particularly that group which constitutes the greater number—those suffering from malignant disease, and we must not rely entirely upon any one method or theory.

Once a malignant growth has metastasized, permanent cure is not to be expected by any means. Surgical statistics do not give us any great hope, particularly if we exclude those cases with enlarged glands of inflammatory origin. In my personal observations I have been disappointed with the results of postoperative and pre-operative raying. I have seen very rapid recurrence take place, even recurring in the skin of patients who were at the time being subjected to heavy roentgen therapy.

When a patient suffering from malignant disease presents himself at the clinic, he should be considered in the following manner:

1. Is there any evidence that the disease has metastasized? If not, complete removal by surgery should be undertaken at once with every hope for permanent cure. If metastasis has taken place, we must decide whether we are going to attempt a complete cure or whether our treatment shall be palliative. If we decide that there is hope of a complete cure, surgery is still probably the method of choice, but I believe that where extensive dissections are required, the results will be disappointing. If surgery is not attempted, then we may treat with *x*-ray or radium or both, and here again two methods are open to us.

2. Shall we attempt a complete destruction of the malignant cells regardless of the pain and discomfort which we are likely to cause the patient, even continuing the dose to a point which brings on actual sickness, or shall we confine ourselves to a dose which will not produce painful erythema, keeping the number of areas so limited that the patient's natural resistance will not be destroyed by repeated attacks of sickness, and using a ray of not too great penetration, with a distance sufficiently great to warrant an even distribution through the part being rayed?

In this way we may hope to inhibit the growth of the malignant cells, and at the same time stimulate the production of a limiting envelope of connective tissue.

When one considers the extremely small number of cures of malignant tumors by any method after metastasis has taken place, I believe the latter procedure is more rational. In this way life is prolonged and made comfortable. The superficial lesions—such as the large ulcers—are avoided, and death occurs usually from deep metastasis.

Recently we have had a small group of cases of carcinoma of the breast in which there was evidence of metastasis, glands being palpable in the axilla and above the clavicle. For this or other reasons they were not operated on, but were subjected to *x*-ray treatment alone. These cases have certainly done much better than similar cases operated upon and followed by radiation.

I cannot but feel that the operation in some way breaks down the natural resistance of the patient, and interferes with the wall-

ing-off process which is the result of connective tissue stimulation.

In the treatment of non-malignant disease it is quite possible that it is not necessary to attempt cell destruction, but that a dose sufficient to inhibit cell activity maintained over a considerable period of time is all that is necessary or required.

Waters in his experiments on dogs and rabbits was unable to produce any definite changes in the thyroid gland unless the dose was sufficiently large to produce permanent injuries to the skin.

My own observations in the treatment of hyperthyroidism rather confirm this idea. I have yet to see a case of myxedema proved positively to be due to *x*-ray treatment. Cases have occurred while under radiation, but myxedema is a fairly common end resultant in hyperthyroidism.

A small group of cases which suddenly dropped to below normal under treatment have since returned to normal, suggesting that their symptoms were due to inhibited glandular function rather than destructive. A case of malignant thyroid, who has had heavy radiation off and on since 1913, has a metabolism to-day which is only ten points below normal. The average radiologist doing fluoroscopic work has his thyroid region exposed to a considerable amount of radiation of a short wave length. If the amount received is very small it should produce stimulation. If it is sufficiently large it should destroy the gland. With this idea in mind, I recently had my own metabolism done, and it was a few points below normal. Apparently the amount of radiation which I have received has had no stimulating effect upon the thyroid gland. It would be interesting, I think, if other radiologists would have this simple test made.

In closing, I again wish to call your attention to the necessity of developing a group of clinical workers in our large *x*-ray laboratories, and to the importance of better cooperation with the internist and surgeon. What little success we have had in the treatment of goiter at the Massachusetts General Hospital has been due, I am sure, to a very large extent, to the good cooperation which we have had with the clinical laboratories, the internists and the surgeons.

The cases have been very carefully selected. The progress of the treatment has been followed by all available means, and no therapeutic measure which would be of benefit to the patient, such as rest and sedative drugs, has been neglected. What is true in the treatment of goiter is equally true in the other diseases which we are called upon to treat.

THE REDUCTION OF RADIOGRAPHIC EXPOSURES TO ONE TWENTY-FIFTH OF THE NORMAL AMOUNT BY MEANS OF THE "IMPEX" X-RAY PLATE

By DR. LEONARD LEVY, M.A. (Cantab.) F.I.C.

AND

T. THORNE BAKER, ESQ.

LONDON, ENGLAND

THE question of the reduction of radiographic exposure to the lowest amount possible is one of the utmost importance to all roentgenologists. Progress in this direction has for many years past been achieved almost entirely by increasing the power of the unit supplying the high tension discharge and by the improvement of the *x*-ray tube. Some advance has been effected by improvement of intensifying screens, by the use of which excellent radiographs can now be obtained, with a ratio of reduction in exposure of one-fifth to one-tenth according to the subject.

In spite of the fact that sufficiently powerful apparatus is in existence to permit of exposures of a fraction of a second on any medical subject, the demand for still further rapidity on the part of the *x*-ray plate is as insistent as ever, not only to reduce the period of exposure, but to enable the distance between the *x*-ray tube and the plate to be increased in order to obtain better definition.

If the various measures taken to effect reduction of exposure be considered, it is somewhat remarkable that for many years past the speed of the plates employed for radiography has remained practically constant. It would almost appear, indeed, that with the present type of plate a limit has been reached.

In view of this fact, that the speeds of all plates produced by various manufacturers of the highest repute are about the same, it does not appear to be likely that experiments upon the ordinary lines of plate manufacture would lead to a considerable reduction in the exposure required. A trifling increase in speed might possibly be attained, but a considerable multiplication could not reasonably be expected.

For these reasons, it was thought best to consider the production of a plate upon entirely new lines, and the question of the production of a plate and intensifying screen in one soon presented itself as a possible solution. We had been aware for a long time that the normal reduction of exposure effected by an intensifying screen, say 10-1, was by no means the limit attainable with the plates available and with the type of calcium tungstate used for the production of intensifying screens. For example, if the salt were coated on the screen with just sufficient emulsion to retain it on the backing, an increase of speed of 15-1 could be obtained (as compared to the usual 10-1). Such a screen would be useless in practice as the surface is too fragile. This observation served, however, as an indication, and it might reasonably be expected that a still closer contact between the fluorescent substance and the sensitive film might well lead to a considerable further increase in the efficiency of the salt as a means of reducing exposures.

The fluorescent material might be mixed in with the emulsion before coating. This method would not, however, be likely to be effective unless the fluorescent material were transparent. In addition to this the resulting image would almost certainly be grainy and the method of production would to some extent defeat its own object. Owing to the separation of the particles of reduced silver on the plate by the particles of fluorescent salt, the net effect of this construction would

be to reduce exposures to a certain extent on this account.

The alternative method of production is to have the fluorescent material coated as a layer in contact with the sensitive film. A plate for radiography, constructed in this manner, must fulfil certain desiderata before it can be considered. These requirements are:

1. Technical perfection of the resulting radiograph. The image must be absolutely free from grain and from any mechanical faults, and must be equal in this respect to radiographs made from ordinary *x*-ray plates without intensifying screens.

2. With certain subjects both perfection of detail and degree of contrast leave something to be desired in the case of ordinary *x*-ray plates. In these respects it is desirable that a new plate should not merely equal but should excel existing types of plates.

3. The cost of the new plate must not be materially greater than that of existing plates.

4. The use of the new plate must not introduce any manipulatory difficulties. It should be just as simple to use and to develop as the existing type of plate.

In order that these desiderata may be completely fulfilled, it is quite obvious that the fluorescent material must be far more effective than it is in the case of the most efficient intensifying screens so far produced. If the radiographs produced by the use of an ordinary *x*-ray plate and an intensifying screen are considered in the light of the desiderata mentioned, it will readily be perceived that none of the requirements are properly fulfilled. For example:

1. The screen image is always slightly more grainy than a radiograph taken without a screen.

2. When an intensifying screen is used, mechanical faults are liable to occur owing to particles of dust on the screen—the surface of the latter becoming soiled, or to bad contact due to inefficient or warped cassettes, etc.

3. The fitting of a screen and plate into a cassette is a little troublesome and means multiplication of screens and cassettes for a sequence of exposures.

4. The cost of the fluorescent material per screen if coated on a plate would increase the cost of the latter several hundred per cent.

If the fluorescent material were coated on the plate so as to be in optical contact with the light-sensitive emulsion, we may reasonably expect to obtain a much better result, because there will be no absorption of the fluorescent light by any coating medium before it has a chance to affect the light-sensitive film.

After a large number of experiments a plate has been produced which we believe marks a considerable advance and in which the desirable characteristics which have been enumerated have been completely fulfilled.

This plate, which has been given the name of the "Impex" plate, was first described at a meeting of the Roentgen Society in December, 1920. The present paper, while it embodies all the introductory information contained in the first communication, contains in addition a variety of facts concerning the application and use of the new plate, which facts have become known as a result of the actual manufacture and use of the plate on a large scale.

DESCRIPTION OF THE IMPEX PLATE

The Impex plate consists essentially of an *x*-ray plate coated with a special type of silver-bromide emulsion, on which is coated as a second layer a small quantity of specially prepared fluorescent calcium tungstate.

The light-sensitive emulsion is composed of specially hardened gelatine, in order to facilitate the subsequent removal of the fluorescent coating (henceforth termed the "Impex layer") without any injury to the former.

The coated plate is exposed for a very short period, which may be anything from one-twentieth to one-thirtieth of the normal exposure and which varies with the nature of the object to be radiographed and the hardness of the tube (q. v.). Before develop-

ment the plate is placed in warm water for two or three minutes, when the top layer containing the calcium tungstate dissolves off. The final portions of this coating can if necessary be removed by rubbing with a pad of cotton-wool. Owing to the special nature of the light-sensitive emulsion, the latter is entirely unaffected by this treatment, and the plate is then developed and fixed in the usual manner.

If the plate is placed in the vertical plane, in a tank containing warm water, the top layer dissolves off and sinks to the bottom. A slight rinse under the cold water tap is all that is necessary before developing and fixing in the usual manner.

MODUS OPERANDI OF THE IMPEX LAYER

It will at first sight appear that the Impex plate is merely a combination of a plate and intensifying screen in one. Such, however, is *not* the case. The method of construction of the plate is such that entirely new and hitherto unknown factors are beneficially brought into play, with the result that the characteristics of Impex radiographs differ both from radiographs taken with ordinary *x*-ray plates and from those obtained by the use of an ordinary plate or double-coated film with intensifying screen or screens.

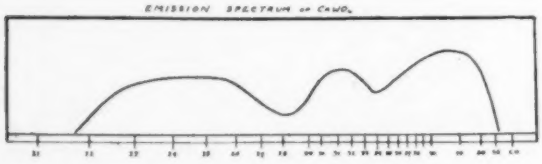


FIG. 1. Emission spectrum of calcium tungstate.

The fluorescence of calcium tungstate under *x*-rays may now be considered. The authors have proved by experiment that if the calcium tungstate is in optical contact with the silver bromide emulsion, it is thirty to fifty times more efficient in reducing exposure than it is if used in the form of an intensifying screen. This observation immediately brought the question of the coated plate into the realm of practical realization. The reason for this enormously enhanced efficiency is elucidated by the accompanying curve showing the emission spectrum of the fluorescence of calcium tungstate when excited by *x*-rays. (Fig. 1.)

It will be observed that a considerable proportion of the fluorescence of this salt occurs in the ultra-violet region. These short waves are entirely absorbed by the various media of which intensifying screens are constructed, and their actinic effect upon the plate is therefore entirely lost. In the Impex plate they are completely conserved, and the results prove that these short waves are many times more potent actinically than the longer waves which are the only ones effective in the case of intensifying screens.

The sensitive emulsion of the Impex plate is treated so as to possess two maxima of sensitiveness, one in the blue violet (visible) and another in the ultra-violet, the center of which is about $\lambda = .245\,\mu$. These correspond fairly approximately to two of the maxima in the emission spectrum of calcium tungstate when excited by *x*-rays. This interadjustment of sensitiveness of the emulsion to the emission spectrum maxima is responsible for a considerable increase in the speed of the plate.

Apart from speed, the optical contact of the Impex layer on the sensitive emulsion has the effect of totally eliminating graininess on the resulting negative. However tightly an intensifying screen is pressed against the film of the plate during exposure, it is never possible to get anything like true optical contact, and the resulting irradiation due to imperfect contact between the fluorescing material and the sensitive emulsion militates against obtaining the best definition.

MANIPULATION OF IMPEX PLATES

A. *Removal of Impex Layer.*—The Impex layer is readily soluble in water at a temperature of 105° to 110° F. (The precise temperature is immaterial.) A convenient method of removing this layer is by standing the plate in a tank containing warm water at about 110° F. A number of plates are placed

in the tank and are removed for development as required. After standing for two or three minutes, the Impex layer dissolves off and sinks to the bottom of the tank. A rinse for a few seconds under a cold-water tap, together with a slight rubbing with a tuft of cotton-wool, serves to remove the residual powder which still adheres to the plate. By the use of the tank method of removal, the increase of time required is less than one half minute per plate and the manipulation is actually quicker than using an intensifying screen. The plates are quite uninjured by being left in the warm-water tank until it is convenient to proceed with their development. If preferred, however, each plate may be treated separately in an ordinary developing dish containing warm water. A preliminary soaking of three minutes serves to render the Impex layer easily removed by a tuft of cotton-wool when swilled under a cold-water tap.

B. *Development.*—Owing to the fact that the emulsion has absorbed water during the removal of the Impex layer, it is desirable to use developer of rather more than the usual strength. This counteracts the dilution which it experiences on diffusing into the wet film. Equally good results can be obtained with developer of ordinary strength, but the development will require a little longer for its completion. Great care must be taken that the developer is completely in solution; otherwise black spots are certain to be produced.

C. *Fixation.*—The plate is fixed in an acid-fixing bath in the usual manner. Owing to the special nature of the emulsion, fixation is rapid and is complete in less than five minutes. Very little density is lost in this operation. The plates should not be exposed to actinic light until completely fixed.

D. *Safe-lights.*—The excessive sensitiveness of the Impex plate to ultra-violet light renders it necessary to employ a suitable safe-light. A special greenish yellow light is recommended, the transmission spectrum of which is shown in Figure 2 (top). Some green and orange safe-lights transmit ultra-violet light and are thus unsuitable, but a good ruby light is perfectly safe.

A comparatively slight amount of light-fogging considerably reduces the sensitiveness of the emulsion to *x*-rays, and hence the importance of employing a safe-light of the correct type is obvious.

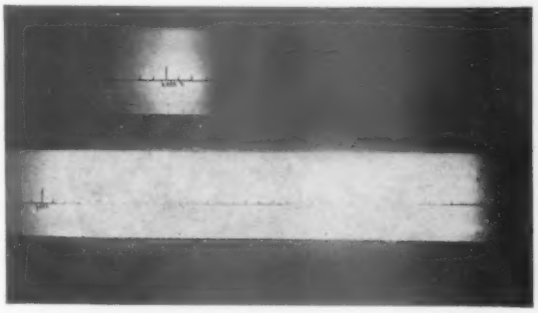


FIG. 2. Transmission spectrum of safe-light.

CHARACTERISTICS OF IMPEX RADIOGRAPHS

A. *Reduction of Time of Exposure.*—1. As already stated, the calcium tungstate is, quantity for quantity, at least thirty times as efficient as when it is used in an intensifying screen. If an intensifying screen and a sheet of glass, coated with the same layer of calcium tungstate as is applied to the new plate are exposed to *x*-rays, it will be perceived that the visible illumination of the screen is many times greater than that of the plate —which is very feeble indeed. In spite of this fact, the effect photographically of the coating on the plate is four times as great as that of an intensifying screen.

2. In the radiography of the thinner parts of the body, such as the foot and knee, the exposure is reduced to one twenty-fifth of the normal exposure required with the *x*-ray plate already in use. Figures 3 and 4 show respectively an ankle and a knee taken on the Impex plate with one twenty-fifth of the normal exposure for these subjects. The details shown in the bones may be noted.

Figures 5 and 6 are respectively radiographs of a foot in a boot, Figure 5 taken on an ordinary plate and Figure 6 taken on an

Impex plate with one twenty-fifth of the exposure. These radiographs are reproduced by the kind permission of Dr. Thurstan Holland.

In the radiography of the thicker portions

FIG. 3. Radiograph of ankle taken on Impex plate.

of the body, such as the pelvis, the exposure is reduced to about one twentieth of the normal amount at present required. Figures 7 and 8 are comparison radiographs of a head. Figure 7 is taken on an ordinary plate and Figure 8 on an Impex plate with one twentieth of the exposure.

B. *Freedom from granularity and clearness of image.*—The fact should be emphasized that in contradistinction to all exposures made with an intensifying screen, the results obtained with the Impex plates are entirely free from graininess and are equal in this respect to the best results obtained with the present *x*-ray plates without a screen, which require twenty to thirty times the exposure. It is practically impossible to over-expose the new plate. Should it accidentally be given two or three times the necessary exposure it is only necessary to reduce the final development; the resulting negative is just as brilliant as if the correct exposure had been given. No graininess at all is produced in cases of overexposure as is the case when intensifying screens are employed.

With regard to contrast in such a subject as the pelvic region and in regard to detail and brilliancy of the image, the Impex plate compares very favorably with the ordinary plates at present in use. Another advantage, which is directly due to the very short exposure required, is the superior sharpness of outline obtained owing to the relative immobility of the patient, who is capable of keeping perfectly still for the very short exposure required with the new plate, but who cannot possibly do so for a much more prolonged period.

C. *Gradation and Range.*—It is generally recognized in radiography that the shorter wave-lengths—as emitted by a hard tube—give less contrast and conversely the negative obtained with a soft tube is more brilliant, provided the penetration is adequate for the subject radiographed.

FIG. 4. Radiograph of knee taken on Impex plate.

The scale of gradation obtainable with an *x*-ray plate of the ordinary type is therefore strongly selective. The technique of the Impex plate is, however, entirely different. Hard rays excite a far more powerful fluor-

escence in the Impex layer and the tube should always be worked in a hard condition—preferably about 7 inch equivalent spark-gap or more.

This method of working does *not* destroy definition in the very soft tissues, for which very *hard* rays, and these are the conditions in which the maximum reduction of exposure, coupled with the greatest detail and contrast, are obtained. This point requires special emphasis, as in certain cases where the maximum reduction of speed was not

FIG. 5. Radiograph of foot in boot taken on ordinary plate.

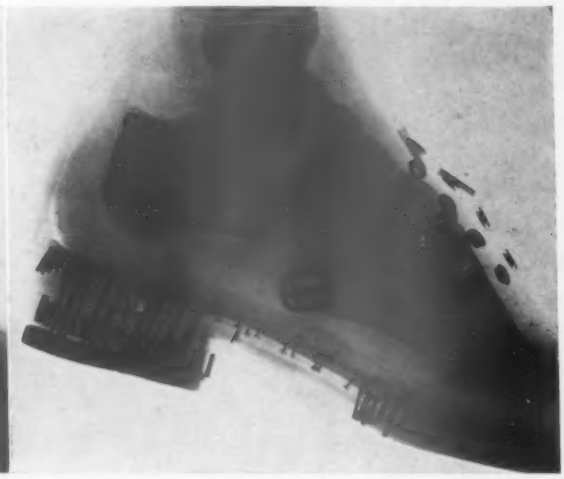


FIG. 6. Radiograph of foot in boot taken on Impex plate with one twenty-fifth the exposure.

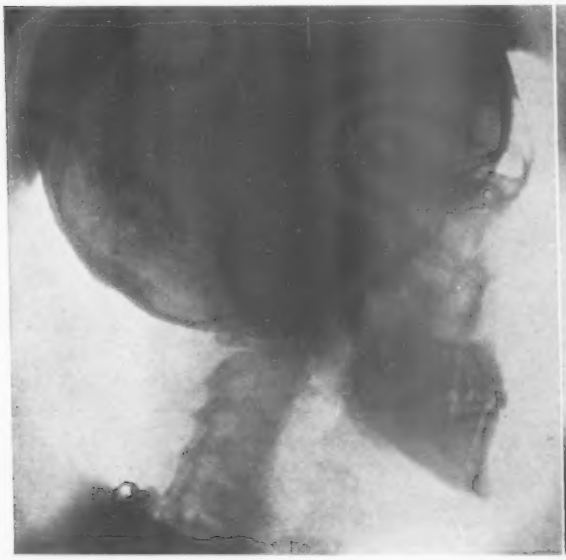


FIG. 7. Radiograph of head taken on ordinary plate.

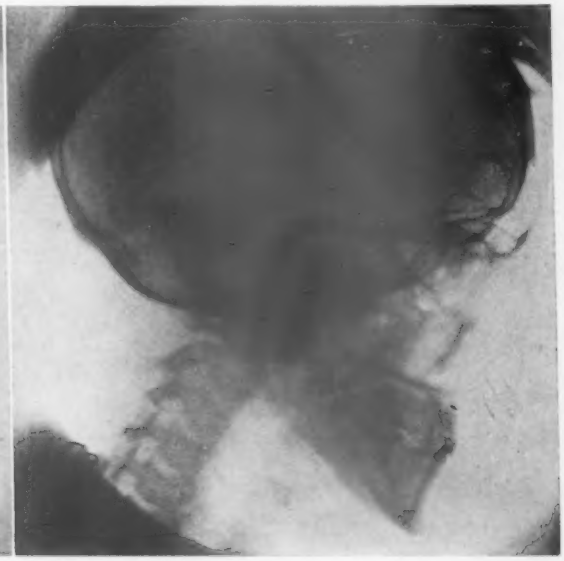


FIG. 8. Radiograph of same head on Impex plate with one twentieth the exposure.

in the ordinary way a soft tube would be employed. The full scale of gradation and in fact, a far wider scale than has been obtainable before, is obtained with the Impex plate exposed under the *softest* tissues with obtained, this was found to be due to the use of too soft a tube. For example, at 4 inch equivalent spark gap, the reduction is only 4 to 1.

The great reduction of exposure will un-

doubtedly be of considerable service in the *x*-ray examination of metals and the like. This is a comparatively recent development of radiography and suffers at present from the drawback of requiring very extended exposures in order to penetrate masses of metal. The reduction of, say, 20-1 on a 20 minutes exposure, means far more actually than the same ratio of reduction on an ordinary exposure of, say, 20 seconds or less required for the radiography of the body. The prejudicial effects of secondary radiations when radiographing considerable thicknesses will be obviated. Figures 9, 10 and 11 are radio-metallographs taken in the fraction of a second on the Impex plate, the ratio of reduction of exposure being about 30-1. Figure 9 is an alarm clock radiographed in its case. Figure 10 is an electric switch. Figure 11 is a direct vision spectroscope. The flint crown glass prisms are clearly differentiated.

FIG. 9. Alarm clock radiographed in its case.

The great reduction of exposures afforded by the use of the Impex plate is advantageous in many other respects. The possibility of taking the number of radiographs without the risk of burns and without the production of other undesirable results is of course perfectly apparent.

A by no means negligible advantage is that of the reduction of wear and tear upon apparatus, especially upon tubes. The number of exposures per tube is greatly increased, and whereas during the course of a comparatively long exposure a gas-filled tube will often vary its vacuum and so give rise to variable results, this trouble should not be experienced with the very short exposures necessitated with the new plates.

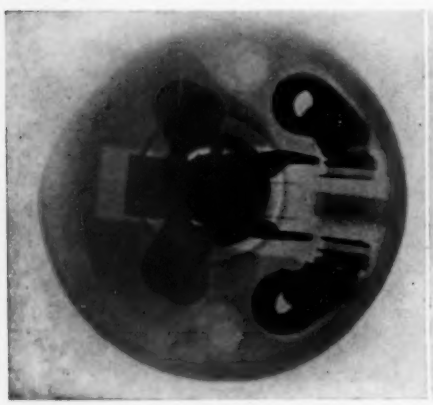


FIG. 10. Electric switch.

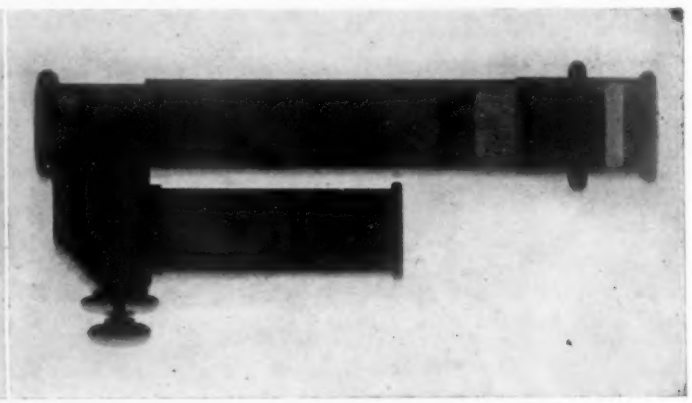


FIG. 11. Direct-vision spectroscope with flint crown glass prisms clearly differentiated.

The capacity of low power installations is considerably increased. Results can now be obtained with a 12 inch and even with a 10 inch low capacity coil set which were formerly possible only with far more expensive and powerful outfits.

The results so far obtained are to be regarded as purely preliminary. It is hoped that further experimentation will enable still better results to be obtained. By inter-adjustment of the absorption spectrum of the film to the color of the fluorescence of the intensifying salt used, a further improvement may confidently be expected, and the reduction of exposure to even 1/100th of their present values should not prove an impossibility.

Various new possibilities present themselves. For example, a cinematographic radiograph of the heart beating should be readily obtainable with ordinary apparatus.

Double coated films can be made on the same lines as the new plate, each light-sensitive emulsion being provided with its removable fluorescent layer. It may also be confidently anticipated that the radiographic examination of metals and other materials will be carried out on objects at present not attempted owing to the large exposure necessitated.

The experiments leading to the invention of the Impex plate were undertaken at the instance of the Cox-Cavendish Electrical Co. Ltd., of London, for whom the preliminary work was carried out in Dr. Leonard Levy's laboratory.

The great speed of the Impex plate is undoubtedly due in part to the use in its preparation of a special ultra-violet sensitive emulsion which had previously been developed for screen plates in the laboratory of the Imperial Dry Plate Co., Ltd., under the direction of Mr. Thorne Baker, who was also responsible for working out the manufacturing details concerning the coating of the Impex layer.

THE EFFECT OF RADIUM EMANATION ON THE ADULT MAMMALIAN BRAIN*

An Experimental Study upon Animals, with Special Reference to the Therapeutic Dose in the Treatment of Brain Tumor

By HALSEY J. BAGG, PH.D.

From the Huntington Fund for Cancer Research, Memorial Hospital

NEW YORK CITY

THESE experiments are primarily concerned with the histological changes following exposure of the adult brain to radiation from radium emanation, and the extent to which a normal brain may be radiated without destroying normal functional activity.

It is well known that adult nervous tissue is resistant to radiation, and from experience in the treatment of neoplasms other than those of the brain, one would expect that certain cellular types of cranial tumors would react favorably to radiation.

The unsatisfactory results of surgical removal of brain neoplasms justify this preliminary work, designed to obtain data for the treatment of such growths by physical agents. The question of dosage and technique in utilizing the large supply of radium now at the Memorial Hospital becomes pertinent. It will be appreciated that the methods of utilizing the radium emanation from four grams of radium metal may be quite different from those employed by previous workers using only a few hundred milligrams of the element.

Brain tumors have been treated for some time by means of radiation. The *x*-rays have generally been utilized alone, and in several cases combined with radium. Quick[1] in his recent paper on the utilization of radium and *x*-rays in the treatment of hypophyseal tumors has given a fairly complete bibliography of the more important papers. Fewer reports have concerned the use of radium alone in the treatment of such growths, and by far the most extensive is a recent paper by Frazier[2] reporting several years of experience. Simultaneously with Frazier's recent report, his associates, Williamson, Brown, and Butler[3], gave a preliminary account of an experimental study of the effects of radium on normal brain tissue. Fortunately, the work of the writer, begun over two years ago, tends to extend and supplement rather than repeat the later investigations. Their principal results, as well as the previous researches in this field, will be discussed later on in this paper.

METHODS AND APPARATUS

Four methods were used: 1. Unfiltered† radium emanation contained in minute glass tubes was permanently inserted beneath the scalp in small animals (rats), and directly in the brain tissues in others—rats, guinea pigs, rabbits and dogs. Small doses of radium emanation were used in this group, each tube containing from 0.2 to 1.5 millicuries. 2. Larger doses of unfiltered radium emanation, 63 to 255 millicuries, were placed in the brains of rabbits and dogs and left in place for varying periods. 3. A comparatively large amount of radium emanation, filtered by 1 mm. of platinum, and contained in a capsule applicator, was inserted in a dog's brain for thirty-five minutes. 4. Two large doses of heavily filtered radium emanation, 4000 and 9000 millicurie hours respectively, were applied externally over the head, in the case of dogs, and a still larger dose of 12,030 millicurie hours was applied in a similar manner over the left temporal region of a monkey.

†That is, the only filter was from 0.1 to 0.2 mm. of glass.

*Read by invitation before the New York Neurological Society, New York Academy of Medicine, Dec. 7, 1920.

The small glass tubes containing radium emanation vary from 2.5 to 4 mm. in length, and are about 0.4 mm. in outside diameter, with containing walls about 0.1 mm. thick. The trocars were 0.8 mm. in diameter at the small end, at which place the radium tubes were inserted. After the trocar was inserted in the tissues, it was slightly withdrawn before pressure on the stylet released the radium tube. For further details concerning this technique see References 4, 5, and 6. The radium was inserted into the brain through a small hole, 2 to 4 mm. in diameter, drilled in the calvarium.

FIG. 1. The monkey before treatment, and the apparatus (puzzle-box) used in establishing motor habits. (For further reference see text.)

The larger doses of unfiltered radium emanation, used in the second method, were contained in glass tubes, 10 mm. long, 0.6 mm. in diameter, with walls about 0.2 mm. thick. These were thrust directly into the brain tissue, and a fine piece of surgical silk was tied at one end to facilitate their withdrawal.

The platinum capsule was 20 mm. long, 3 mm. in diameter, with walls 1 mm. thick. A stiff steel rod, fitted into the upper end of the capsule, served as a means of thrusting the applicator into the brain. This accomplished, the rod was removed, while a fine wire, also attached to the upper end of the applicator, was used in withdrawing the tube after the treatment.

The so-called "lead tray" that was used for the treatments of heavily filtered radium emanation, gave a filtration of 2 mm. of lead and 0.5 mm. of silver. The applicator was held at varying distances from the scalp, as will be described later. In treating the dogs a lead shield, 2 mm. thick, protected the parts of the head that one did not desire to treat. The radiation reached the brain mainly through a rectangular opening (2 cm. by 4 cm.), cut in the shield. The radium tubes were arranged over a correspondingly large area on the floor of the applicator.

The rats and guinea pigs were operated upon under light ether anesthesia. The rabbits and dogs were given subcutaneous morphine injections. One quarter grain was sufficient for a full-grown rabbit, while three quarters to one grain were used for the dogs, depending on the size of the animal. About one grain was given to a 15 kilo. dog. When the radium was inserted into the brain, a 1 per cent novocain solution was used as a local anesthesia in addition to the morphine. For the surface applications of heavily filtered radium, it was necessary to quiet the animals for from two and a half to five hours. In these cases, morphine alone was used.

A monkey was selected as a subject because it was thought that it might exhibit more delicate locomotor disturbances, and more especially defects in digital manipulations, than could possibly be detected in the case of dogs and the other animals. In order to obtain more accurate objective data than are generally given for this type of experimentation, certain motor habits were established before the brain was exposed to radiation. A time record was made of the learning process and notes were taken concerning the individual differences in behavior peculiar to the animal. The puzzle-box shown in

Figure 1 was used. At first the animal's daily task consisted in opening the door of the box, which would swing forward when a central catch, as shown in the illustration, was set at the vertical position. Its food, previously placed within, was then obtainable. When this task was learned the situation was complicated by the addition of the lower catch, and finally, when both of these could be manipulated at once, the higher latch was added. Ample opportunity was afforded the experimenter to study possible disturbances or variations in the several distinct motor habits that eventually became fixed in the animal's behavior.

EXPERIMENTAL RESULTS

1. *The effect of small amounts of unfiltered radium emanation upon brain tissue.*— The localized effect of radium destruction was the most marked feature of the method wherein the brain was radiated by small amounts of unfiltered radium emanation. In all cases the destroyed tissue was an elliptical solid, with a necrotic area in the center, in the immediate proximity of the radium tube. This necrotic area was about 5 mm. in diameter, and was surrounded by a zone, 2 to 3 mm. wide, showing brain cells in various stages of degeneration. In nearly all cases, the total area of well radiated tissue was about 1 c.c., generally exactly that amount, seldom less, and never but 1 to 2 mm. more in diameter. That this reaction was due to the radium emanation and not to the presence of the glass tube, or the traumatism incident to its insertion, was previously determined in a control experiment.[6]

A pronounced feature associated with these lesions was a leukocytic infiltration, which tended to wall off the radiated area from the normal brain tissue. This is well shown in Figure 2, and in this case the infiltration was due to polynuclear cells. The lesion was caused by an unfiltered tube of 1.2 mc. placed over the calvarium above the right cerebral region, and left there for forty days. The scalp immediately above the tube was destroyed over an area of 8 mm. by 10 mm. The brain lesion showed a central necrotic area, about 5 mm. in diameter, around which was a zone of polynuclear leukocytes, while beyond this was a broad region showing hyperemia and some pial edema. The ganglion cells near the necrotic zone showed marked hydropic degeneration

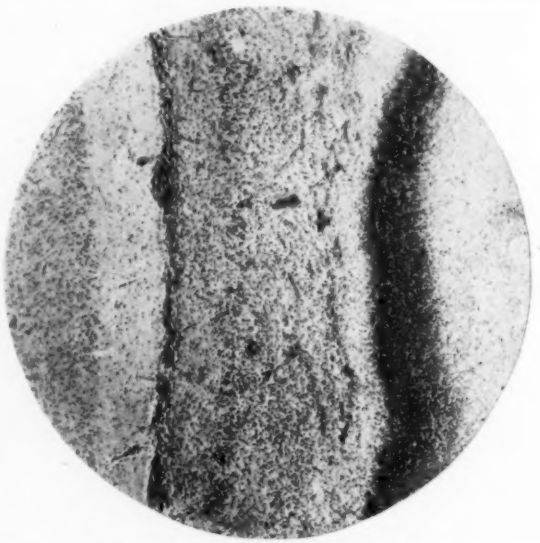


FIG. 2. High power view of a section of a rat's brain, showing the edge of a lesion in the superior portion of the right hemisphere, well localized by a marked area of leukocytic infiltration. A small glass tube, containing 1.2 millicuries of radium emanation was placed between the calvarium and the scalp, and left in place for thirty days. At the right is shown a portion of the area of necrosis, next the zone of leukocytes, and a wide area of hyperemia. (For further reference see text.)

and all the nuclei stained poorly. There were minute blood extravasations, with some increase in the small compact nuclei in this area, and the pia showed marked round-cell infiltration. The cells of the adjoining convolutions showed chromatic bodies that did not stain well. There was pericellular and perivascular edema.

The localized action of buried small doses of radium emanation is again shown in the lesion indicated in Figures 3, 4, and 5. A single tube of 1.1 mc. was inserted in the brain of a young dog on November 17, 1919, and was allowed to remain there permanently. During the following month the dog (here called dog A) showed no appar-

ent neurological disturbances, and at the end of thirty days it was killed and the brain placed in fixative. The gross examination of the brain showed a well circumscribed lesion, 15 mm. below the dorsal convexity, in the mesial gray matter of the cortex just superior to the corpus callosum (Fig. 4). Five millimeters below this level the ventral limits of the lesion extended through a portension became less and less. The total amount of radium emanation was reduced, by a natural process of "decay," 16.5 per cent per day, and this was a continuous process. At the end of four days, the total amount was reduced to about one half.

Similar brain tissue reactions were obtained with other animals, rats, guinea pigs, and dogs, also treated with small doses of

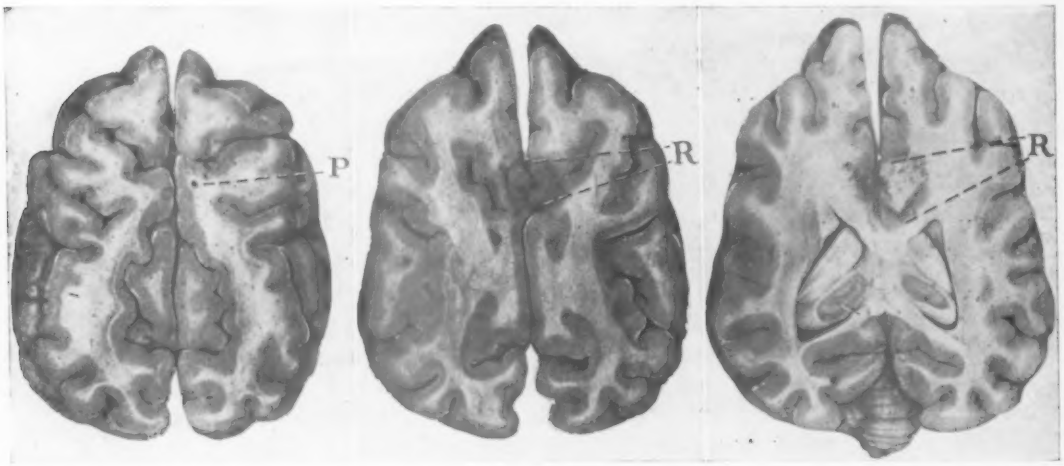


FIGURE 3. FIGURE 4. FIGURE 5.

FIG. 3. (P indicates point of insertion.) Section of the brain of dog A, 11 mm. below the surface, showing the point of insertion of the radium trocar. FIG. 4. (R indicates radiated area.) Section of the brain of dog A, 15 mm. below the surface, showing the lesion produced by 1.1 mc. of unfiltered radium emanation. Dose = 127 mc. hrs. Time = thirty days. FIG. 5. (R indicates radiated area.) Section of the brain of dog A, 20 mm. below the surface. The ventral limit of the lesion is about 2 mm. below this level.

tion of the genu of the corpus callosum, and on the right side involved a small part of the internal capsule (Fig.5). The lesion was about 10 mm. in diameter, and was sharply marked off from the normal brain tissue surrounding it. Histological examination showed necrosis at the center surrounded by a zone about 2 mm. wide showing edema and destruction of nerve tissue.

The dose in the above case was 127 mc. hrs., and the lesion was produced by a relatively small amount of radium emanation acting over a comparatively long period. To understand the nature of this reaction, one must remember that at the time the radium emanation was placed in the brain it radiated the tissues with a maximum intensity, but during the following days the intensity became less and less. The total amount of radium emanation was reduced, by a natural process of "decay," 16.5 per cent per day, and this was a continuous process. At the end of four days, the total amount was reduced to about one half.

Similar brain tissue reactions were obtained with other animals, rats, guinea pigs, and dogs, also treated with small doses of unfiltered radium emanation. It was found from these experiments that a considerable amount of brain substance could be destroyed without producing apparent neurological disturbances. This matter will be discussed later.

II. *The effect of a comparatively large amount of unfiltered radium emanation upon brain tissue.*—A large amount of unfiltered radium emanation gave a much more extensive and intensive tissue reaction than any recorded in Section 1. This was so although the dose in number of millicurie hours remained the same as that received by dog A, i.e., 127 mc. hrs. On March 22, 1920, at 4 P. M., a tube containing 255 mc. was inserted into the brain of an adult dog

(dog B) and left in place for thirty minutes (255 mc. for one half hour = 127 mc. hrs.). The tube was thrust into the brain through a hole in the calvarium. The following morning the dog showed signs of brain disturbances. It lived for four days and during that time there was a progressive development of a left hemiplegia (note the "foot drop" of the forward limb, and the abnormal position of the hind limb on the left side, as shown in Figure 6), with blindness of the left eye, and a pronounced tendency to turn to the right. At the end of four days the dog refused food, it became comatose, and as recovery appeared hopeless, it was killed by ether anesthesia.

FIG. 6. Photograph of dog B, four days after treatment with 255 millicuries of unfiltered radium emanation for thirty minutes. Dose = 127 mc. hrs. There is a left hemiplegia, and left eye blindness. (For further reference see text.)

A gross examination of the brain, 21 mm. below the dorsal convexity, showed a large, well circumscribed, hemorrhagic lesion, 17 by 18 mm. in diameter, involving a large portion of the right thalamus, extending from the region of the hippocampus to the inferior border of the section of the head of the caudate nucleus appearing at that level, and completely intersecting the fibers of the internal capsule (See Figures 7, 8, and 9). On microscopical examination the lesion

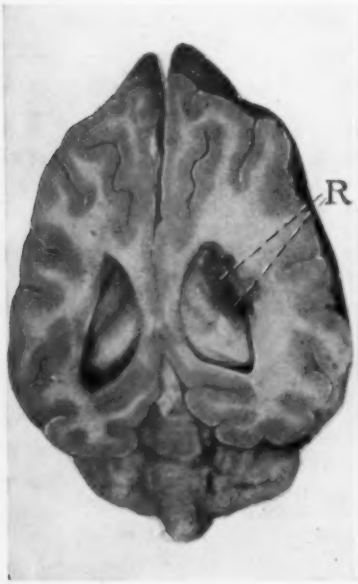


FIGURE 7.

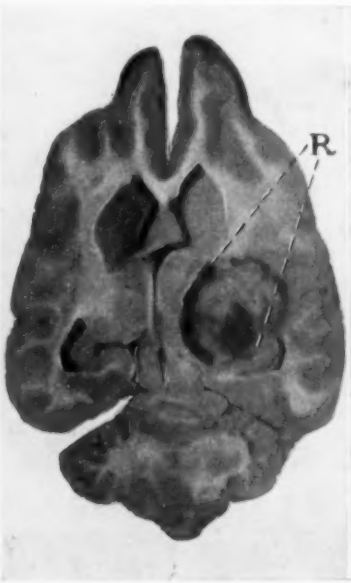


FIGURE 8.

FIGURE 9.

FIG. 7. (R indicates radiated area.) Section of the brain of dog B, 13 mm. below the surface, showing the dorsal limits of a lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes. (For further reference see text.) FIG. 8. R indicates radiated area.) Section of the brain of dog B, 21 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes. FIG. 9. (R indicates radiated area.) Section of the brain of dog B, 28 mm. below the surface, showing the ventral limits of the lesion produced by 255 millicuries of unfiltered radium emanation for thirty minutes.

showed a central area of brain softening, 10 mm. in diameter, with extravasated blood, thrombosed blood-vessels with necrotic walls, and granular necrotic brain tissue. The necrotic vessels, surrounded by hemorrhage, extended to the periphery of the area. About the lesion there was a concentration of polynuclear leukocytes, and a zone of hydropic degeneration of nerve tissue, while the ganglion cells for a considerable distance beyond this area showed a loss of chromatic bodies. In the velum interpositum there were hemorrhage and considerable leukocytic exudate.

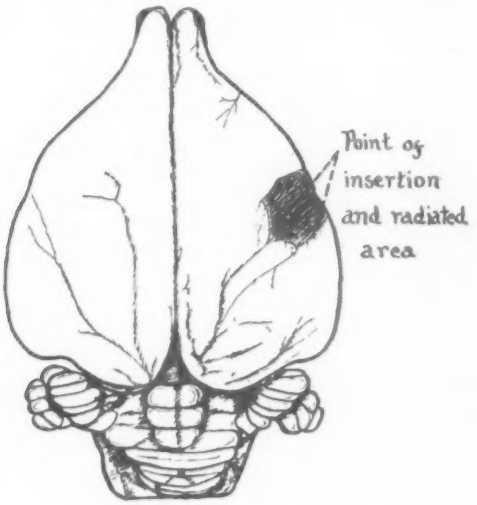


FIGURE 10.

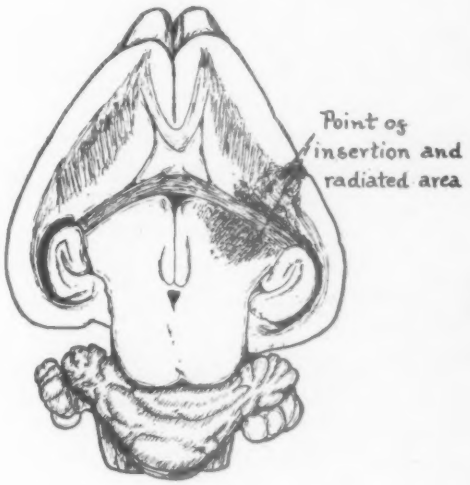


FIGURE 11

FIG. 10. Dorsal view of the brain of rabbit A, showing the lesion produced by 63.5 millicuries of unfiltered radium emanation for two hours. Dose = 127 mc. hrs. FIG. 11. Section of the brain of rabbit A, 8.5 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 63.5 millicuries of unfiltered radium emanation for two hours. Dose = 127 mc. hrs.

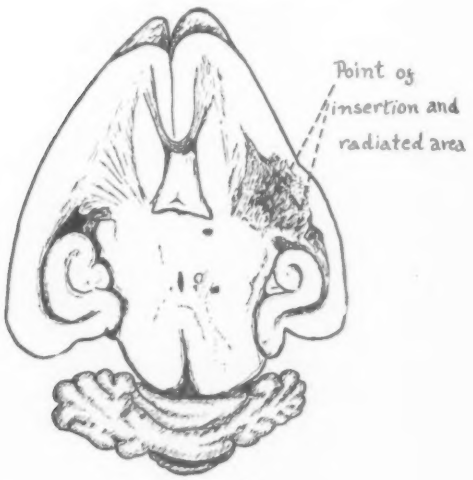


FIGURE 12.

FIGURE 13.

FIG. 12. Section of the brain of rabbit B, 9.0 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 241 millicuries of unfiltered radium emanation for fifteen minutes Dose = 60.2 mc. hrs. FIG. 13. Section of the brain of rabbit C, 8 mm. below the surface, showing the maximum extent of the diameter of the lesion produced by 241 millicuries of unfiltered emanation for ten minutes. Dose = 40.1 mc. hrs.

The remaining tests with comparatively large doses of unfiltered radium emanation are given in Figures 10 to 13 inclusive. Three large adult rabbits were used, approximately the same region of the brain was treated in each case, and the same methods were employed as were used for dog B.

Rabbit A was treated with 63.5 mc. for two hours, this again being a dose of 127 mc. hrs. The treatment was completed at 5 P. M., and the animal was found dead early the next morning. The extent of the destruction of the cortex at the surface was 6 mm. by 8 mm., as is shown in Figure 10. Figure 11, sketched at a level 8.5 mm. below the surface of the brain, shows a lesion 12 mm. in its largest diameter, involving the fornix on the right side, the corpus striatum, the adjacent cortex, and mesially a portion of the thalamus. The type of degenerative tissue change was essentially similar to that reported for dog B, except that there is a much richer exudation of polynuclear leukocytes in the pia mater over a wide area of the surrounding tissue.

Since these experiments are largely concerned with the extent of tissue reaction in response to the intensity and duration of radiation, the two remaining animals, rabbits B and C, were treated with comparatively large amounts of radium emanation for very short periods, so that the number of millicurie hours, as compared with the amount received by rabbit A, was much less.

Rabbit B received 241 mc. of unfiltered radium emanation for fifteen minutes. The dose was 60.2 mc. hrs., about one half the dose for rabbit A. This animal also died during the following night. In this case the gross tissue change, as shown in Figure 12, covered an area 8 mm. by 10 mm. in diameter, at a level 9 mm. below the surface of the brain. The lesion at this level was largely confined to the corpus striatum, but it extended to the cortex above as a solid mass of degenerative tissue. The lesion was essentially similar to that of rabbit A.

The lesion shown in Figure 13 was produced by the same radium tube that was used in the above experiment, i.e., 241 mc., and it was left in the brain of rabbit C for ten minutes. This dose was 40.1 mc. hrs., and the animal, as in the other cases, died during the following night. The lesion, 8 mm. below the cortical surface, was largely confined to the angle between the hippocampus and the fornix. It extended dorsally to the cortex, and ventrally it involved a small portion of the right cerebral peduncle. It is interesting to note that in this case, although the number of millicurie hours was reduced to 40.1, the area of destroyed tissue was still 6 mm. by 8 mm. in diameter.

III. *The effect of inserting into the brain a comparatively large amount of filtered radium emanation.*—Dog C was a large adult female. A platinum capsule with walls 1 mm. thick, containing 218 mc., was inserted into the brain and left in place for thirty-five minutes. The dose was 127 mc. hrs. As a result of the treatment the dog showed no apparent neurological disturbances, and remained well and active for the following month. At the end of that time it was killed by ether anesthesia. Gross examination of the brain revealed a comparatively small lesion, situated in the region of the superior portion of the internal capsule on the right side, and not more than 3 mm. in diameter. The microscopical examination showed a focus of softened brain tissue, with an accumulation of Gluge's corpuscles, some blood pigment, and a few foreign body giant cells surrounded by a new growth of spindle cells. The whole section had a cicatricial appearance. For a considerable distance about this area there was an accumulation of many perivascular lymphocytes and plasma cells. The focus was 3 by 4 mm. in diameter.

IV. *The effect of radiating the brain with an external application of heavily filtered radium emanation.*— Dog D was a well-grown female, about one year old. After being quieted by morphine, its head was protected by a lead shield, save for a rectangular opening 20 mm. by 40 mm. in diameter, which permitted radiation to reach the left cerebral hemisphere. The shield was 2 mm.

thick. The "lead tray" previously described, containing 1965 mc. of radium emanation, was placed immediately over this opening and left there for two hours and twenty-five minutes. The dose was 4,000 mc. hrs. The total filter for the left cerebral region was 0.5 mm. of silver and 2 mm. of lead, and the distance was 2 mm. About fourteen days after the treatment a moderate radium dermatitis appeared over the treated area, which later was surrounded by a 10 mm. zone of alopecia. This area extended slightly beyond the midline of the head. No other symptoms were noted, and the dog remained well and active, showing no apparent neurological disturbances for a month after the treatment. At the end of that period it was killed by ether.

A gross examination of the brain showed nothing abnormal, save possibly a slight congestion of the cortical blood vessels. The microscopical examination showed no changes either in the brain substance or the pia. The ganglion cells appeared normal and stained well. The blood vessels in the subcortical fiber tracts were sheathed with 1 to 3 layers of plasma cells, and there was a little blood in some of the perivascular lymph sheaths.

In treating dog E the same applicator and shield were used, but the distance was increased to 50 mm. The treatment consisted of an exposure to 1800 mc. for five hours, the dose being 9,000 mc. hrs. A 50 mm. gauze pad kept the applicator at the proper distance, and tended to decrease the secondary radiation from the surrounding metal surfaces. The pad did not change the character of the radiation that reached the brain, but it served better to protect the scalp. The dog was well and active after the treatment, and showed no neurological disturbances. The scalp remained normal except for a very slight loss of hair. At the end of a month the dog was killed by ether anesthesia. The brain was apparently normal from a gross examination. Microscopical examination showed the pericellular nuclei in the gray matter apparently increased in number. The Nissl substance in the ganglia cells was indistinct. The pia was apparently normal, there was a slight increase in the perivascular nuclei, but no vascular changes were noticeable.

Tissues from the radiated portions of the brains of dogs D and E were treated by Marchi's stain and Sudan III, but no degenerations were found in either case.

The monkey, which was the last animal in the series, was treated with the "lead tray" containing 2406 mc. for five hours. The application was made over the left temporal region, at 10 mm. distance, but in this case the shield was not used. The left side of the brain was radiated because the animal invariably used its right hand in manipulating the catches. Ten millimeters of rubber served to reduce the secondary radiation. As in the other cases, the filter was 0.5 mm. of silver and 2 mm. of lead. The dose was 12,030 mc. hrs.

It was not until eight days after the treatment that any clinical symptoms appeared. First was noticed a huskiness of voice, accompanied on the tenth day by pronounced salivation, and a beginning erythema over the left side of the face. The animal at this time was somewhat inactive. Except that the animal suffered greatly from the effects of a severe radium burn of the face, no neurological symptoms were noted that could be definitely attributable to brain disturbances brought about by the radiation. However, on the nineteenth and twenty-third days after the treatment a temporary fine tremor of the front limbs appeared, but this condition was not seen at any other time, and later disappeared altogether.

There was no evidence to show that radiating the brain directly interfered with the retention of the motor habits that were established before treatment. The experiment was adjusted to show possible deficiency in the digital manipulations, but nothing abnormal was noted in this regard in the handling of the various catches in the post-radiation series. A few minor changes were noted in the method of approaching the task, but no clumsiness or asynergia was apparent in its execution.

Judging the permanence of retention of the habit by the average speed of its accomplishment, the results show that one cannot conclude that radiating the brain in this particular animal materially increased the time of the reaction. The records in the accompanying Table I show that when due consideration is given to the probable error attached to each average, there is very little difference between the performance in the last twenty trials before, and the twenty-four trials after the treatment. In fact, the last ten trials, the last of which was taken only two days before death, show a considerable quickening of the average performance, despite the fact that the general physical condition of the animal, due to the radium burn, was poor. The animal became comatose on the thirty-third day following the treatment, and died the next morning.

At autopsy the brain was found to be apparently normal, except for a certain amount of anemia of the smaller cortical blood-vessels of the left temporal region in the area which was directly exposed to the radiation. The relative appearance of the various aspects of the brain is shown in Figures 14 and 15. Careful microscopical examination of the portion of the brain directly beneath the radiated area revealed no definite degenerative changes.

FIG. 14. Lateral view of the left side of the brain of a monkey after exposure to 2406 millicuries of heavily filtered radium emanation for five hours. Note the obliteration of the smaller cortical blood-vessels in the temporal region. (For further reference see text.)

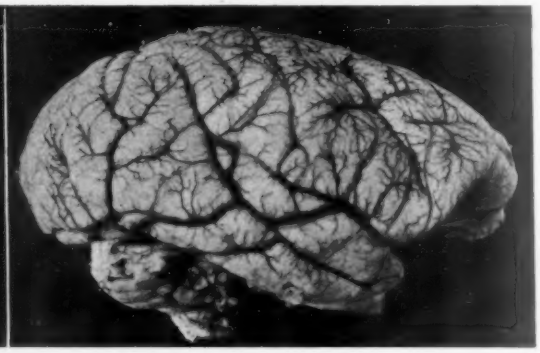


FIG. 15. Lateral view of the right side of the brain of the monkey after radiation.

TABLE I.

TIME AVERAGES FOR THE PERFORMANCE OF THE MONKEY IN THE BEHAVIOR TEST (PUZZLE-BOX REACTION)

	No. Secs.	*Probable Error*	*Mean Variation*
Average per trial for last 20 trials before treatment	26.4	± 3.0	15.9
Average per trial for 24 trials after treatment	38.8	± 6.4	36.2
Average per trial for first 14 trials after treatment	56.8	± 11.9	50.9
Average per trial for last 10 trials after treatment	13.6	± 1.4	4.9

DISCUSSION OF RESULTS AND SUMMARY

Danysz[7] (1903-1904) reported the presence of hemorrhages in the brain and spinal cord of mice exposed to radium. After 1 mg. of radium salt had been placed in con-

tact with the exposed dura mater of a rabbit for eight hours, hemorrhages were noted in the central nervous system, but no changes could be detected in the actual nerve elements.

Heineke[8] (1903) obtained similar results, and stated that deep hemorrhagic softening spread from the spot at which the radium tube had been applied.

Scholtz[9] (1904) and Okada[10] (1905) irradiated the sciatic nerves of young rabbits in the first case, and rabbits and frogs in the second, and although in both cases strong tissue reactions occurred, the nerves showed no alteration.

Obersteiner[11] (1905) treated the brains of white mice with capsules containing 10 and 50 mg. of radium bromide, and concluded that the irradiation had no specific effect on nervous tissue, and the derangements that occurred might be accounted for by the destruction of the small blood-vessels, which resulted in considerable hemorrhages in the brain substance.

Horsley and Finzi[12] (1911) applied a platinum tube, 0.5 mm. thick, incased in 1 mm. of rubber, and containing 55 mg. of radium bromide, to the precentral and postcentral gyri of the brains of monkeys. (On Rutherford's standard the amount of pure metallic radium was 22.7 mg.) Two animals received treatment for two and a half hours, and showed no disturbance at the end of twenty-six and thirty-one days when they were killed. Another animal was treated in three places over the brain with a tube containing the equivalent of 100 mg. of radium bromide, and it showed no disturbance up to the fifty-fourth day, when it also was killed. The writers noted in the meninges "endothelial proliferation of the walls of the blood-vessels, in some cases practically occluding the lumen." Punctiform hemorrhages were noted in the cortex, in one animal, as deeply as the fifth layer of the cortex. They conclude that "radium rays, from which the less penetrating beta rays have been filtered off, and employed in a strictly clinical procedure, exert no influence discoverable by present methods on the nerve tissue, but do cause notable changes in the blood-vessels."

Williamson, Brown, and Butler[3] applied 50 mg. of radium bromide over the motor area of the cortex of dogs. A platinum tube, with walls 0.4 mm. thick, was placed under the dura for four, six, twelve, and eighteen hours. Rubber was not used to absorb the secondary radiation from the platinum. None of the dogs showed disturbing symptoms after the application. The writers noted a 4 mm. area of necrosis beneath the tube, which showed thickening and hyalinization of the blood-vessels without rupture of their walls. Beyond this area, for a zone 1 mm. wide, was a region showing cells with evidences of degeneration, and ruptured blood-vessels producing hemorrhagic infiltration. The line of demarcation from this area to the surrounding normal brain tissue was sharp. There was no cellular infiltration, except from the hemorrhage, and no evidence of beginning repair. These investigators conclude that "the application of radium to the brain of the dog, under certain limitations as to time and strength, has a destructive action, but produces no clinical symptoms."

The writer's results confirm, in the main, the previous reports concerning the so-called resistance of nervous tissue to filtered radium. The additional information herein recorded is concerned with the localized beta-ray effect of small tubes containing small amounts of radium emanation, the more intense, extensive, and promptly destructive reaction following the insertion in the brain of comparatively large doses of unfiltered radium emanation, and finally, that the brain may be externally radiated, through both the scalp and skull, by large amounts of heavily filtered radium emanation, radiating from a comparatively large surface applicator, and the nervous tissue still may show no signs of degeneration.

In a previous paper[6] attention was called to the localized effect of buried tubes containing small amounts of radium emanation in various kinds of tissue, and it was noted that nervous tissue was no exception to this rule. The present experiment extended this

observation to different parts of the brain in various animals. In practically all cases the volume of degenerated tissue was one cubic centimeter, generally exactly that amount, seldom less, and hardly ever more than 1 to 2 mm. more in diameter. This localized reaction is probably due to three reacting factors: first, the dispersion of rays is increased the greater the distance from the source, so that the tissue in the immediate proximity of the tube receives the maximum intensity of radiation; second, the beta rays are largely absorbed by a few millimeters of tissue (see the recent work of Quimby[13] in this regard); and third, the inflammatory reaction of the surrounding tissue, leukocytosis, etc., also tends to localize the reaction.

The slow, localized brain tissue reaction, in response to radiations from small amounts of unfiltered radium emanation, gradually diminishing in strength, is usually associated with no neurological disturbances. This type of reaction, associated with unilateral brain destruction, may be such that compensatory adjustments have sufficient time to bring about apparently normal physiological reactions. These results are similar to the gamma-ray reactions recorded by Horsely and Finzi for monkeys, and Williamson, Brown and Butler for dogs.

There is an entirely different physiological and histological reaction associated with exposing the brain to comparatively large doses of unfiltered radium emanation. The intensity of radiation in the vicinity of the tube is greatly increased, hemorrhagic infiltration is extensive, and the entire process is so rapid that the adjustment of the organ as a whole is impossible and fatal terminations soon occur. Comparing the above results one may see that the physiological and histological reactions in response to a small amount of unfiltered radium emanation (mainly of beta-ray activity) acting over a comparatively long period, are not similar to an equal dose consisting of a much larger amount of radium emanation acting for a correspondingly short time.

Previous investigators have emphasized the local nerve tissue reaction due to gamma radiations from applicators placed on the surface of the brain. The results of the present experiments extend this observation to gamma radiation when acting beneath the cortex.

The final contribution of this paper deals with the radiation of the brain, through the scalp and skull, by heavily filtered radium emanation. Here again is emphasized the ability of nervous tissue to withstand a considerable amount of gamma-ray radiation. The applications were made as in a strictly clinical procedure, and the dose was as strong as those employed in the therapeutic treatment of certain types of cancer. Although the dose, in the case of the monkey, was increased to the limit of skin endurance, there still was no apparent physiological disturbance in brain function, and, except for an obliteration of certain of the smaller cortical blood vessels in the radiated area, no anatomical change was noted, and there was no apparent degeneration in the structure of the nervous tissue.

The behavior test, employed in a careful study of the animal's habit reactions before and after exposure of the brain to intense radiation, revealed no cerebral disturbance. The average daily time record, associated with the opening of a fairly complicated puzzle-box, was about the same after the treatment as it was before.

CONCLUSIONS

1. Of the four methods that have been tested, the application of heavily filtered radium emanation over the scalp may be considered a relatively safe procedure for the treatment of brain tumors.

2. The burying of small doses of unfiltered radium emanation (mainly beta-ray radiation) is also suggested as a favorable method of treating such growths.

3. The relatively sudden destruction produced by comparatively large doses of unfiltered radium emanation makes this

method unsafe for the treatment of brain tumors.

4. While the applicability of imbedding filtered radium emanation is still uncertain, it is possible that by using still larger doses than were employed in these experiments, and decreasing the filtration, this method may also be of use.

5. It was noted that nervous tissue was markedly resistant to gamma-ray radiation, and this reaction is probably associated with the relatively adult condition of the nerve cells.

6. The changes in the brain following radiation were largely due to the destructive action of radium emanation on the blood vessels.

7. There was a marked localized reaction, associated with a pronounced leukocytic infiltration, following the insertion of small doses of unfiltrated radium emanation in the normal brain. These lesions were especially interesting, because of the absence of neurological symptoms.

8. In the case of a monkey that received a strong dose of heavily filtered radium emanation over the brain, there was no subsequent loss of previously established motor habits.

The writer wishes to acknowledge his indebtedness to Dr. James Ewing for his advice concerning the pathological changes observed in the histological material, and to Dr. Beatrice Fairbanks for preparing and diagnosing sections from the brains of two of the dogs.

REFERENCES

1. Quick. *Arch. Ophth.*, 1920, xlix, 256.
2. Frazier. *Surg. Gynec. & Obst.*, 1920, xxxi, 236.
3. Williamson, Brown and Butler. *Surg. Gynec. & Obst.*, 1920, xxxi, 239.
4. Duane. *Boston M. & S. J.*, 1917, clxxvii, 787.
5. Failla. *Arch. Radiol. & Electrol.*, 1920, xxv, 3.
6. Bagg. Am. J. Roentgenol., Nov., 1920, vii, 536.
7. Danysz. *Compt. rend. Acad. d. sc.*, 1903, cxxxvi, 461; 1903, cxxxvii, 1296.
8. Heineke. *München. med. Wchnschr.*, 1903, 2090.
9. Scholtz. *Deutsche med. Wchnschr.*, 1904, xxx, 94.
10. Okada. *Arb. a. d. neurol. Inst. a. d. Wien. Univ.*, 1905, xii.
11. Obersteiner. *Arb. a. d. Neurol. Inst. Wien. Univ.*, 1905, xii, 96.
12. Horsley and Finzi. *Brit. M. J.*, 1911, ii, 898.
13. Quimby. Am. J. Roentgenol., Oct., 1920, vii, 492.

THE AMERICAN JOURNAL OF ROENTGENOLOGY
H. M. IMBODEN, M.D., *Editor* · PAUL B. HOEBER, *Publisher*

Issued Monthly. Subscription, $6.00 per year. Advertising rates submitted on application. Editorial office, 480 Park Avenue, New York. Office of publication, 67-69 East 59th Street, New York.

Information of interest to all readers and lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on the two pages preceding Table of Contents.

CORRESPONDENCE

London, 24th June, 1921.

To the Editor:

Dear Sir: We have noticed with interest an article in the April number on "The Practical Application of the Sphere Gap to Roentgenography," by Dr. H. J. Ullmann. Since the early part of 1920 we have been advocating the use of sphere gap voltmeters measuring continuous or peak discharges up to 250,000 volts, as we have realized the great value of adding such a sphere gap voltmeter to every *x*-ray outfit.

The importance of measuring the voltage applied to an *x*-ray tube is becoming generally recognized, but the problem is not too easy with the high voltages that obtain in *x*-ray practice. The work of Peek and others has shown that a spark gap between spherical electrodes of equal size is a convenient and accurate means of measuring high voltages. The spark between points is now generally discredited for high voltages on account of its liability to inconsistency and its dependence on atmospheric conditions and frequency of discharge. By reason of its variable time-lag, its readings may on occasion be 300 or 400 per cent in error, in the case of high frequency steep impulses.

On the other hand, frequency and wave shape have no appreciable effect in the case of the sphere gap, and the effects of variation in the atmospheric conditions are well known, and can be readily corrected for.

The size of the spheres is important. A good rule is not to use a gap bigger than the diameter of either of the balls, though some latitude may be permitted in this direction. The main point is to avoid the break-down discharge being preceded by brush-discharge or corona, otherwise a pulsating discharge will, in general, give gap readings too high.

With the above precaution, a sphere gap is a reliable instrument capable of measuring voltages from say 10,000 volts to 500,000 to an accuracy of about 2 per cent.

The gap should not be exposed to any extraneous ionizing influence, such as an arc or an adjacent spark, nor should the gap be enclosed. The first spark is the one for which the reading should be taken. A continuous spark can readily be blown out by the mouth or other means, and so prevented from lengthening out when the gap is widened.

HOWARD C. HEAD, *Director.*
WATSON & SONS (Electro-Medical) LTD.

Atlanta, Ga., Aug. 17, 1921.

To the Editor:

I have noted with interest the instructive paper of Dr. W. O. Upson concerning transposed viscera, appearing in your July issue.

Within the last two years two cases have come under my observation. One, a fairly well-nourished man of forty-four, who suffered from typical duodenal ulcer symptoms, and who showed definite pathology of the duodenal cap, exhibited a complete transposition of both the thoracic and abdominal organs. Two of his brothers and two sisters were fluoroscoped, but were normal.

The other was a young and husky man, who was applying for entrance in the navy. The examining physician discovered that his heart was on the right side and sent him to me for examination. He, too, showed a complete transposition of his thoracic and abdominal organs. The latter individual was a fine specimen of physical manhood, and insisted that he had never suffered from any illness whatever from his youth to the present.

GEO. M. NILES, M.D.

BOOK REVIEWS

THE ROENTGEN DIAGNOSIS OF DISEASES OF THE ALIMENTARY CANAL. By Russell D. Carman, M.D., Head of Section on Roentgenology in the Division of Medicine, Mayo Clinic, and Professor of Roentgenology (Mayo Foundation) Graduate School of Medicine, University of Minnesota. Second Edition thoroughly revised. Containing 676 pages with 626 original illustrations. Price $8.50. W. B. Saunders Company, Philadelphia, 1920.

This excellent book has achieved its second edition. It carries an additional 98 pages, new illustrations to the number of 122, and 2 new chapters. One of the chapters is upon "Hour-Glass Stomach" and the other "A Chronological Abstract of the Published Work of Pneumoperitoneal Diagnosis of Abdominal Lesions."

The book is printed upon rather thin paper and carries the 676 pages in an easily handled volume which is excellently bound in a flexible back.

There is no doubting the fact that this text book is the most thorough exposition of abdominal roentgenology in any language. There is sufficient new and revised material to demand the re-purchase of this edition by those who have appreciated the first edition.

E. H. SKINNER.

MEDICAL ELECTRICITY, ROENTGEN RAYS, AND RADIUM, with a Practical Chapter on Phototherapy, by Sinclair Tousey, A.M., M.D., Consulting Surgeon St. Bartholomew's Clinic, New York City. Third edition, thoroughly revised and greatly enlarged, containing 1337 pages, 861 practical illustrations and 16 in colors. Price $10.00. W. D. Saunders Company, Philadelphia, 1921.

Tousey truly states in the preface that it is practically impossible to write a book on electricity which will be up to date, because of the many rapid changes.

This book contains a great deal of valuable information concerning electricity in the numerous forms which are applicable to medicine, devoting chapters to static and dynamic electricity, electricity occurring in animals and plants, the physiological effects of electricity, electro-pathology, electro-diagnosis and electro-therapy.

In addition he devotes a chapter to physical reconstruction after war injuries, in which he mentions the testing of nerve injuries, nerve testing at time of operation, and electro-treatment of nerve injuries. He then discusses the physiological and therapeutic effects of the electro-magnets, electricity in disease of the nervous system from a diagnostic and therapeutic standpoint, and at the end of this chapter he takes up the physiological causes of death by electricity. The chapters on high frequency currents are very comprehensive. He devotes 546 pages, with numerous illustrations, to the roentgen ray, approaching it from the standpoint of physics, then the localization of foreign bodies, roentgenography, development of roentgenograms, and fluoroscopy. He then describes his technique for roentgenography of all portions of the body. He writes at some length on roentgen therapy, including his technique. The last forty pages are devoted entirely to radium—radium activity, radiochemical, physiological and pathological effects, and therapeutic uses. There is a very complete and extensive index.

The book is valuable, in that it serves as an excellent reference book.

W. W. BELDEN.

TRANSLATIONS & ABSTRACTS

The Protection of Roentgenologic Workers. (London Letter of the *J. Am. M. Assn.*, xxvii, No. 1.)

The committee for the protection of roentgenologists, which was announced in a previous letters (The Journal, April 23, 1921, p. 1181), has been formed. The chairman is Sir Humphry Rolleston. The members are Sir Archibald Reid, radiologist to St. Thomas' Hospital; Dr. Robert Knox, radiologist to King's College Hospital and the Cancer Hospital (representing the British Association for the Advancement of Radiology and Physiotherapy); Dr. S. Gilbert Scott, radiologist to the London Hospital; Dr. Stanley Melville, radiologist to St. George's and to the Brompton Chest hospitals (representing the Electrotherapeutic Section of the Royal Society of Medicine); Dr. Harrison Orton, radiologist to St. Mary's Hospital; Mr. Cuthbert Andrewes (representing the Röntgen Society); Prof. S. Russ, physicist to the Middlesex Hospital (representing the Institute of Physics); Dr. G. W. C. Kaye (representing the National Physical Laboratory), and Dr. J. C. Mottram, pathologist to the Radium Institute. The committee held a preliminary meeting and appointed a sub-committee to draw up a statement, to be issued as a leaflet, on the means for the protection of the workers, giving advice as to the position of roentgen-ray rooms, their ventilation and cubic space, and on the need for making and observing rules governing the hours of work, outdoor exercise and holidays of workers. The committee intends to collect data on the effect of irradiation with particular reference to protection; to carry out special research; to act in a consultative and, possibly, advisory capacity, and to publish reports from time to time.

Funk, Elmer H. Malignant Diseases of the Lung. (*Med. Clin. N. Am.*, March, 1920, p. 1197.)

New growths are not frequent in the lung, and are often mistaken for pulmonary tuberculosis. "Among 1200 patients sent into the wards of the chest department of the Jefferson Hospital with the diagnosis of advanced tuberculosis, 72 or 6 per cent were incorrectly diagnosed and of this number 5 were instances of malignant disease of the lung." Among 551 postmortem cases collected by Ash from different tubercular institutions, 61 were non-tubercular; 11 per cent of these were primary neoplasms. Passler from a total of 1000 autopsies found 16 primary carcinoma, and 5 primary sarcoma of the lung; Seydel, 184 malignant tumors of lung and pleura from 10,829 autopsies; 16.8 per cent were primary, 83.2 per cent secondary. Adler, 374 cases of primary carcinoma, 90 were sarcoma. "Secondary carcinoma may arise from an initial focus in the abdomen or from extension of a mammary, esophageal or thyroid tumor. Metastatic sarcoma most often originates from a primary growth in one of the long bones."

As yet there is no known primary cause of malignant tumors. For several years trauma in various forms has often been observed to precede the malignant disease. Irritation, such as dust, etc., has also been thought to play a part, and may account for the predominance of the disease.

The symptoms may be latent. However, in most instances, especially in the primary growths, there are definite signs and symptoms. These depend upon the size, origin, situation and rate of growth of the tumor. The local symptoms are shortness of breath, cough, pain and pressure effects. The general symptoms are progressive weakness, loss of weight, secondary anemia, etc.

Roy G. Giles.

Knox, R., London. *X*-Rays in the Diagnosis of Tumors of the Thorax. (*Brit. M. J.*, 1920, ii, 392-395.)

Knox classifies tumors of the thorax as: (1) intrathoracic; (2) extrathoracic; (3) both extra- and intrathoracic. Benign and malignant conditions of the skin, soft parts and bony parts, capable of casting a moderately dense shadow on the negative, are described. Also those of the internal organs of the thorax, mediastinum, heart and pericardium.

The exact determination of origin and site of tumors of the thorax will always be difficult and at times impossible. The majority of intrathoracic tumors, however, arise from the mediastinum. Broadly speaking, an extension out-

ward from the mediastinum will indicate the presence of a tumor, excluding the benign form tumor, such as aneurysm, hydatid cyst. The cause of such shadows in the order of their frequency will be found to be tuberculosis, carcinoma, and sarcoma.

Tuberculosis may give rise to very definite enlargement of the hilus shadows. Tuberculosis of the root glands and mediastinum of long standing is accompanied by degenerative changes.

Carcinoma, though rarely primary, is probably the most common of the primary neoplasms. It is not infrequently secondary. The history is important. The median shadow is nearly obliterated. There is frequent involvement of pleura and very little of lung left. It is often unilateral.

Sarcoma may be primary or secondary. It usually arises in the mediastinum and frequently from the thymus gland, and the edges are irregular.

Secondary sarcoma are common. They show large bulging shadows distorting the larger shadows of the structures in that region. The masses are larger; the density and the edges are more uniform than carcinoma and the nodules are not so numerous.

Syphilis occasionally may involve the lung or bronchi, occurring in two forms, interstitial and gumma.

Tumors arising in mediastinum are prone to give shadows similar to those of an aneurysm, endothelioma or sarcoma. The one differential point of value is the character of the pulsation observed in the tumors. Rarely aneurysm and tumors may occur in the same case.

R. G. G.

MAYO, CHARLES H. The Thyroid and its Diseases. (*Surg., Gynec. & Obst.*, March, 1921.)

The work of Kendall has resulted in explaining the chemical nature of the secretion of the thyroid. The present standardizing of the effect of the thyroid secretion on metabolism is largely due to the work of Plummer, aided by Boothby and Sandiford. The latter's reports are based on about 18,000 metabolic tests. They not only confirmed that hypofunction of the thyroid lowers the metabolic rate and hyperfunction raises it, but by using Kendall's pure thyroxin they have definitely ascertained the amount of thyroxin in the body, the amount normally in the gland, the amount necessary to bring a hypothyroidism to normal and the amount used up each day by the body.

It appears that the thyroid secretion makes available the energy of the cells of the body. This gland enables the individual to develop an available, active, iodinized secretion from the iodides of the food.

Iodine is notably deficient in the thyroid gland in exopthalmic goiter and is variable in the gland of adenoma with hyperthyroidism. The ultimate cause, however, of hyperthyroidism is still elusive. It may be in the chemistry of infection, toxemia produced within the gland or at a distant focus, or a chemical stimulant. Plummer has shown that the condition resembling exopthalmic goiter and known as pseudo-Graves' Disease, etc., is really hyperthyroidism due to adenoma.

One type of hyperthyroidism occurs in goiters of long standing, fourteen to twenty years, and is not accompanied by exopthalmos. The average age of these patients on appearance of hyperthyroidism is forty-three and their average age at operation is forty-eight. In exopthalmic goiter the average age is thirty-six years. Diagnosis can usually be made from the signs and symptoms and determination of the basal metabolic rate. The lymphocyte changes noted by Kocher are not reliable. Epinephrin injections recommended by Goetsch are likely to be misleading and may produce dangerous reactions.

The average age of patients at operation is between thirty-one and thirty-six, but he has seen a few cases between five and ten and a few between fifty and sixty.

The treatment in the adolescent period of simple goiters that do not spontaneously disappear is iodine, thyroid secretion, or thyroid products.

Operation is advised at any age in cases of round encapsulated adenoma causing distress. Partial removal of both lobes with removal of isthmus is performed for goiter of long standing or one resisting treatment.

Cancer of the thyroid is rare. The rapidly growing hard gland if smooth and even is probably due to hemorrhage in the gland structure. A hard symmetrical small gland that is not exopthalmic is possibly tuberculous.

Operations in the early stage of exophthalmic goiter should be as safe as those in simple goiter. Patients with exophthalmic goiter pass

through exacerbations and remissions; during exacerbations they should be medical and surgical patients, and if necessary treated by ligation, *x*-rays, hot water injections, and rest.

A patient with about plus 66 metabolic rate who has survived a recent exacerbation is a better surgical risk than one with rate of plus 46 who is on the rising wave of exacerbation. With *x*-ray treatment remission may occur just as it occurs without treatment or with several other methods of treatment. The writer's experience has been failure or but temporary benefit from *x*-ray treatment. It is possible that *x*-ray treatment may destroy the gland and produce hypothyroidism. He states that it is difficult to regulate the dosage and that its use adds to the difficulties of operation. He hopes that radiotherapy may be developed into a safe and effective method of securing a cure or relief in preparation for surgery.

A. C. C.

CASE, JAMES T. Surgical Physiology and Pathology of the Colon from the *X*-Ray Standpoint. (*N. York State J. M.*, xxi, No. 5,)

The paper is confined to a study of colonic peristalsis under normal and pathological conditions, and to the diagnostic and operative errors into which one may be led if unaware of the changing appearance of the colonic shadow during peristalsis. Emphasis is laid upon the prolonged stay of food residues in cecum and proximal colon, right-sided pain, distention and fullness suggesting appendiceal involvement, due to some obstructing organic or functional lesion in the distal colon or rectum, and to the importance of studying the entire colon, including pelvic loop and rectum, before accepting as the explanation of right-sided pain such rare lesions as adhesions of the terminal ileum or cecum, fixation of the appendix, so-called Jackson's membrane, hepatocolic bands, or ptosis of the transverse colon.

The outline of the normal colon is variable and ever changing. On palpation under the fluoroscopic screen the mobility of all parts of the colon can be demonstrated. The position and shape of the transverse colon is especially variable, undergoing a turning snakelike movement and suffering considerable dislocation without propulsion of its contents. Surgical procedure which aims to fix this portion of the bowel is discredited as interfering with the normal movement.

The prevailing movement in the proximal colon is antiperistaltic, tending to retain material in the cecum. The distal colon has as its characteristic activity a churning and onward movement. Haustral churning occurs constantly in the distal colon. The principal propulsive movement of the colon is the spontaneous large contraction activity to which the term "spontaneous mass movements" is applied. The bowel outline suddenly loses its haustral markings and takes the shape of an ovoid elongated sausage-shaped mass with smooth edges, rounded to the ends. This mass at once begins to move at about twice the rate of a peristaltic wave in the stomach, the rate and distance traversed varying according to the case. When it comes to rest the mass resumes its haustral markings.

During and following the opaque enema one frequently sees a large ring constriction passing along the colon distalwards and sometimes in the antiperistaltic direction.

These various phenomena may lead to diagnostic errors:

1. Pseudo-filling defects due to peristaltic activities simulating the defect produced by neoplasm.

2. Proximal colon stasis, especially cecal stasis due to exaggerated antiperistalsis which may be incorrectly attributed to membraniform or band adhesions involving the cecum, ascending colon or hepatic flexure, or the supposed prolapsus of the transverse colon.

3. A point of arrest in the transverse colon just proximal to the midline which may be erroneously attributed to organic obstruction.

The evidence obtained by *x*-ray study constitutes only one part of the medical examination of the patient, and should be interpreted in the light of the history and other physical and laboratory findings.

L. R. SANTE.

HAWES, JOHN B., 2D. Broncho-Esophageal Fistula and Traction Diverticulum. (*Am. J. M. Sc.*, June, 1921, clxi, No. 6, 791.)

Broncho-esophageal fistula is a rare condition in itself but traction-diverticulum is even more so. Traction diverticula are situated in

the anterior wall of the esophagus near the bifurcation of the trachea and result usually from the extension of inflammatory lesions of adjacent lymph glands with adhesions and subsequent cicatricial contraction by which the wall of the esophagus is drawn out. The diagnosis is readily made with opaque meal and *x*-ray examination. The condition may be suspected clinically but usually a fluoroscopic examination is necessary to confirm the diagnosis. One case of ordinary broncho-esophageal fistula following a long abscess and one of true traction diverticulum are described.

Case 1. Pulmonary symptoms continued for eleven months after pneumonia. A consolidation of the right lung with abscess formation was demonstrated radiographically. Soon after this examination the patient began coughing up large amounts of pus which occasionally was blood-streaked. He was operated, ribs resected and the abscess drained. One week later particles of food taken by mouth were recovered from the chest wound, and the *x*-ray examination definitely demonstrated a broncho-esophageal fistula. The discharge of material from the wound gradually lessened until it healed spontaneously about two months later.

Case 2. The onset of the trouble followed an attack of influenza in 1916. After several months' illness the patient had a large pulmonary hemorrhage. Following this she suffered from hemorrhages for the next three years, being very nervous, prostrated and much under weight. Physical examination at that time showed no evidence of abnormality except in the lungs. There was fairly definite evidence of an old tuberculosis in the right middle and upper lobes. An increase in peribronchial markings was present especially in the region of the middle lobe, and near the mid portion of the lung near the hilus a well-defined cavity was present. There was an associated interlobar thickening of the pleura. This diagnosis of tuberculosis was made in spite of the repeated negative sputum examinations. Sometime more than a year later the patient complained of small particles of food being coughed up in the sputum several hours after ingestion. *X*-ray examinations showed that while a large amount of the barium meal entered the stomach through the esophagus, a small portion remained in a shelf-like ridge over the lower end of the esophagus and part of the barium went into the cavity in the right lung. For six months following the barium meal only one slight hemorrhage occurred; this was a much longer period than had ever elapsed before without a hemorrhage.

The impressions that come from this case have convinced the writer that all cases of pulmonary hemorrhage in which repeated sputum examinations are negative should be studied closely for other causes. That foreign material may enter the lung with impunity and cause no serious damage is quite evident.

L. R. S.

WEIBEL. Vienna. Treatment of Cancer of the Uterus with the Symmetry Apparatus. (*Wien. klin. Wchnschr.*, June 2, 1921.)

This apparatus was devised by Wintz and Baumeister of Erlangen and has been tested in the II Gynecological Clinic at Vienna. Since the autumn of 1920 nine operable and six inoperable cases of cancer of the cervix have been treated. Of the first series three seem to be complete cures, although a biopsy of the tumor site shows a dubious condition of the epithelium. A fourth is on the way to recovery, while of the other five some are refractory to treatment, and others of too recent date to be discussed. Of the six operable cases one half are doing excellently. In discussion Neu-Wirth expressed the opinion that the symmetry apparatus had been thrust too far in the foreground. Irrespective of what apparatus is used the same results may be obtained if the tension, hardness of tube and filtration are the same in all. He enumerates a number of apparatus on the market which give equal results under the same conditions. A good operator will get the desired deep action from any one of them. The symmetry apparatus simply has a big advertising campaign behind it. One is not called on to advertise some manufacturer but simply to mention the tension, dose, filtration, etc. Latzko would invert the usual recommendation of abdominal radical operation for advanced, and vaginal for beginning cancer of the cervix. By doing the radical operation in the beginning case he would expect a very low operative mortality.

The advanced case he would treat by radiation with selected use of the amplified vaginal operation under local anesthesia. He endorses the Erlanger technique.

BIRCH-HIRSCHFIELD. Lesions Produced in the Human Eye by Roentgen Rays. (*Ztschr. f. Augenheilkunde*, 1921, xlv, 199.)

The question of the action of the *x*-ray on the eye is highly practical because this resource is beginning to be used in such affections as glioma of the retina and sarcoma of the choroid. Many have affirmed that intense radiation is harmless to the normal eye. The author, however, showed some years ago that this statement is too optimistic. Alterations may take place in the episcleral vessels, iris and retina and endothelium of the cornea. Recently his early labors have been fortified by results seen in two new cases which are the subject of the present paper. In the first, a man of twenty-eight, who had lost an eye in childhood through traumatism, had recently noted diminished vision in the remaining eye. Examination showed the presence of a tumor of the choriod. During ten days the patient received 600 Fürstenau units with a Coolidge tube, with a 3 mm. aluminum filter. Superficial opacities of the cornea and conjunctival injection resulted, which disappeared shortly. A second session the following month was followed by photophobia, lacrimation and pain. The skin of the eyelids was inflamed, the eyelashes dropped out, and a multitude of punctiform opacities appeared in the cornea, having originated in the epithelium penetrating deeply into the stroma. The conjunctiva was much injected and the episcleral vessels showed alternate contraction and dilatation. The iris and lens seemed normal. While regression was in evidence by the third week, some months elapsed before conditions became quite normal. A third session was undertaken after all reaction symptoms had subsided, with similar consequences. The tumor was arrested in its growth and reduced in size. In the second case the affected eye was sound and had been exposed to the rays without any protection, in connection with the radiation of an epitheloma of the upper eyelid. Five treatments were given during a year, each lasting forty-five minutes, without the production of any reactive changes in the eye. However, two weeks after radiation there were headache and fever, and after each consecutive session progressive intensification of these symptoms with corresponding diminution of vision. The tumor disappeared but the bulbus oculi was left edematous, with dilated and tortuous vessels, and there were both superficial and deep turbidity of the cornea, the pupil dilated and the anterior chamber shallow. Intra-ocular tension was 40 mm., vision nil. The pains in the eye did not yield to miotics and it became necessary to enucleate. The papilla was found to be excavated and there were minute hemorrhages in the retina. The condition was pronounced to be glaucoma. Since the *x*-rays have recently been recommended for this affection the experience of the author appears to show that this advice is premature unless perhaps vision is already lost.

MENARD and POSTEL and CONTREMOULINS. Dangers of Radiography to Third Persons. (*Presse méd.*, May 11, 1921, xxix, 38.)

Menard and Postel mention in their article the danger to which the medical men who are permanently in charge of *x*-ray laboratories are exposed. They are constantly exposed to the rays, and to protect them it is customary to place the tube in a capsule which absorbs the rays, the absorptive power of which varies with the potency of the ray to be used. In the most powerful French installation the tube is placed in a large capsule of special make which allows a filtration of only 36 millionths of the initial intensity. Contremoulin believes that *x*-rays may be propagated to a considerable distance and still preserve their heterogenous character. He showed on April 25th, before the Academy of Sciences, teleradiographs taken at a distance of from 40 to 80 meters with a Coolidge tube and with a spark length of 17 cm. The clear definition and marked contrast of these plates were surprising. Rays traversing this distance are readily absorbed and must in consequence exert a biological action. The author, disbelieving in the impermeability of partitions, placed the tube at a distance of 15 meters from a brick and stone wall 50 cm. thick, behind which he placed a sensitive plate. Four hours later the plate was completely fogged. If such results can be obtained with the softer rays used in radiography and of medium intensity, one should be alarmed at the thought of the effect of the 200,000 volts used in deep radiography in some French installations.